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Recent Developments in E-Learning and M-Learning and their Roles in future Pedagogical Systems and Educational Technologies

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ABSTRACT

The paper reviewed the current literature on e-learning and m-learning from 2004 to 2022 based on the most cited, peer-reviewed, published data from the Thomson Reuters' Web of Science (WoS) database. The resulting thirty-eight (38) materials were comprised of scientific articles, conference papers, books and book reviews. The materials revealed the current status, future developments, along with the challenges and prospects of m-learning and e-learning in literature. The findings showed that the concepts of m-learning and e-learning are not mutually exclusive and bear many similarities. Furthermore, the findings demonstrate that m-learning is not only an offspring but the panacea for the many challenges e-learning which affords users with speedy, cost-effective and on-the-go learning resources. As a result, m-learning has experienced significant growth over the years catalysed by advances in ICT and the widespread availability of the internet worldwide. Other interesting improvements include interactive tools, software and applications along with key computer features to improve the security of users, privacy, and resources. Most notable is public key infrastructure (PKI) and attribute certificates (ACS). Other features aim to enhance interaction and collaboration between students and teachers. In general, the study showed that future of pedagogical systems and educational technologies for the delivery of educational materials and learning resources will be greatly enhanced by the acceptance, adoption, and integration of e-learning and m-learning into the traditional classroom learning environments of the future.

Keywords: *e-Learning, m-Learning, Pedagogy, Learning Systems, Educational Technologies.*

Introduction

Recent advancements in information and communications technologies (ICT) and growing societal needs have created new paradigms for education and training (Khan, 2005; Bates, 2005; McLoughlin and Lee, 2008). In the process, this significantly transformed the manner in which humans disseminate and assimilate knowledge and learning materials. According to Reigeluth and Khan (1994), the growth and availability of innovations in digital and media have enhanced the speed, efficiency and convenience at which information is acquired, processed, and utilized. In addition, the ICT innovations for learning and teaching have eliminated the need for the traditional classrooms and physical contact between learners and teachers around the globe. Furthermore, the ICT innovations have heralded the advent of the twin concepts of e-learning and m-learning, which are educational technologies that evolved considerably over the years (Bates, 2005). The emergence of these technologies has been necessitated by the need for affordable, efficient, accessible, unrestricted and learner-oriented environments for learning and teaching (Khan, 2005).

According to Khan (2005), e-learning is defined as an innovative method that provides a well-planned, interactive, and facilitated environment for learning. As a result, anybody can access, process and utilize various digital technologies, materials and methods suitable for open, flexible, and distributed environment for learning (Khan, 2005; Calder and McCollum, 1998). Based on this definition, the concept of e-learning can be considered a holistic approach for the unrestricted, widely accessible, and ubiquitous acquisition and utilization of

learning materials and resources. Figure 1 presents a pictorial depiction of the concept of e-learning as propounded by Khan (2005).

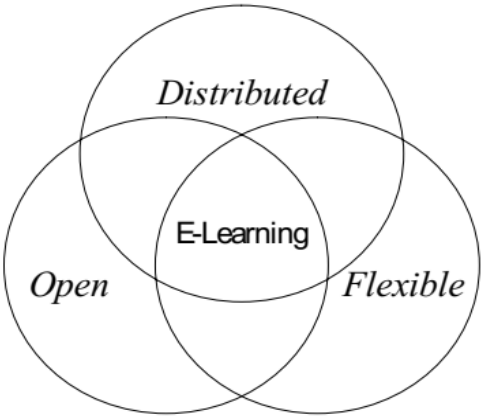

Figure 1: Methodical Concept of E-learning (Khan, 2005)

Based on foregoing, the concept is rooted in the notion that the delivery of education and training materials is not only open but unhindered by any physical barriers. Furthermore, it demonstrates that learning and teaching can occur through various methods and technologies. Over the years, the concept of e-learning (Rennie and Morrison, 2013; Paechter *et al.*, 2010; Garrison, 2011; Bates, 2005), frameworks (Moore *et al.*, 2011; Aparicio *et al.*, 2016; Clark and Mayer, 2016), and strategies (Rosenberg and Foshay, 2002; Button *et al.*, 2014) for its development, adoption and diffusion into currents models (Park, 2009; Urh *et al.*, 2015; Weber and Hamlaoui, 2018) for education and training have been examined by various researchers in literature (Rosenberg and Foshay, 2002; Sun *et al.*, 2008; Park, 2009; Paechter *et al.*, 2010; Garrison, 2011; Moore *et al.*, 2011; Rennie and Morrison, 2013; Button *et al.*, 2014; Urh *et al.*, 2015; Clark and Mayer, 2016; Aparicio *et al.*, 2016; Weber and Hamlaoui, 2018; Hills, 2017).

The study by Rosenberg and Foshay (2002), examined various strategies such as e-learning for the delivery of educational materials and learning resources in the digital age. The authors opined that e-learning has significant prospects for the scalability and effectiveness of employee training in companies. As such companies who do not

transition into e-learning based training delivery, skills acquisition and enhancement of its employees will ultimately fail in the near future (Rosenberg and Foshay, 2002). However, Sun *et al.* (2008) investigated the critical factors that influence the satisfaction of learners and the successful deployment of e-Learning. The study noted that e-learning has become an enigmatic form of delivering modern day education and training that has experienced a growth rate of over 35% over the years. In addition, the authors developed an integrated six (6) dimensions model to investigate the various factors that influence the satisfaction of e-learning users. The results indicated that the six dimensions namely; learners, instructors, courses, technology, design, and environment are critical to the e-learning among users. More importantly, the model identified the learners' perceived satisfaction is influenced by critical factors such as; computer anxiety, instructor attitude, course flexibility, course quality, perceived usefulness, perceived user-friendliness, and evaluations multiplicity (Sun *et al.*, 2008). Similarly, McGill *et al.* (2014) the critical success factors for the prolongation of initiatives designed to actualise e-learning in higher education. The study identified technology issues, developer, instructor-student, and the institution using e-learning as critical factors in the process. Park (2009) examined the behavioural intention to adopt and use e-learning among Korean university students based on the technology acceptance model (TAM). Hence, the SEM (structural equation modelling) technique and LISREL (linear structural relations) program were adapted to examine the behavioural intention to adopt and use e-learning. Based on the results, the most important constructs for e-learning were self-efficacy and individualist norm and attitudes. This was based on the comprehensive analyses of other constructs such as; perceived practicality, perceived user-friendliness, system availability, and behavioural intentions (Park, 2009). Other studies such as Moore *et al.* (2011); Aparicio *et al.* (2016); Clark and Mayer (2016), proposed various concepts, frameworks and guidelines for e-learning usage. The study by Moore *et al.* [9], examined the similarities and differences between various learning systems including e-learning, online learning, and distant learning. Aparicio *et al.* [10], presented and highlighted various concepts and frameworks for e-learning. The findings indicated that e-learning is an ecosystem based on three fundamental principles; technology, services and the users which integrates various strategies, stakeholders and technological systems.

Clark and Mayer (2016) presented comprehensive guidelines for the design and development of multimedia learning, e-learning, and instructional sciences. The study examined the various definitions, factors affecting, design concepts of e-learning. Hence, the authors define the concept, as any form of education instruction that is delivered on a digital device (such as a desktop personal computer, laptop, tablet or smartphone) that is intended to support the process of learning (Clark and Mayer, 2016). However, the definition broadly includes the use of mobile devices such as tablets and smartphones for learning otherwise termed m-learning. This indicates that m-learning and e-learning are not mutually exclusive. As a result, the terms are often used interchangeably to define various forms of education provided beyond the physical boundaries of a brick-and-mortar school. However, there are intrinsic differences.

M-learning is an educational concept introduced in the early 2000s as a medium to explore and exploit the use of mobile devices and communications technologies in education and training (Naismith *et al.*, 2004; Kukulska-Hulme, 2007; Gikas and Grant, 2013; Ally, 2009). Consequently, m-learning typically encompasses the use of personal, ubiquitous, and often cheap mobile devices, by educators and learners alike, to acquire, analyse and assimilate learning and educational materials (Crompton, 2013). Over the years, the use of mobile devices for training and education has become widespread owing largely to the availability,

accessibility, and acceptance of the World Wide Web or the internet (Brown, 2003). Furthermore, the growth of m-learning has been catalysed by the need for convenient, unrestricted, and timely access to information and knowledge worldwide. In spite of this, there remain many debates on the nature of the m-learning concept particularly with regard to acceptable definitions and its overlapping boundaries with e-learning, as described in Clark and Mayer (2016). As a result, many studies have attempted to define the concept. Kukulska-Hulme *et al.* (2009) attempted to define and clarify the meaning and definitions of the concept of m-learning in their study. The findings indicated that the concept is multifaceted and understanding requires breakdown the key tenets based on technology mobility, learner mobility and lastly, the dynamic flow of information during learning. Furthermore, the authors opined that m-learning is an evolving landscape that is dependent on physical, socio-technological, theoretical, and progressive mobility. Cheon *et al.* (2012), examined the readiness of higher education for m-learning using the theory of planned behaviour (TPB). In addition, the study examined the present status of student's opinions on the use of mobile devices in education based on the TPB model. The study also defined m-learning as a novel approach to learning that exploits the benefits of mobile devices for learning. Lastly, the findings revealed that the model successfully explained the student's acceptance of m-learning.

Park (2011) proposed a pedagogical framework for mobile learning. The study also defined m-learning as an important learning tool for students typically integrated with distant learning. Furthermore, the study performed an analysis of various mobile technology-based educational applications which were subsequently classified into four groups. In addition, the study performed a comparative analysis of m-learning with e-learning and described their technical and pedagogic attributes. Lastly, the study proposed a theoretical framework for m-learning based on the transactional distance (TD) theory. Similarly, Motiwalla (2007) proposed a framework for the evaluation of m-learning. The findings demonstrated the potential of SMS (Short Message Service), WAP (Wireless Access Protocols) browsers and W/H (wireless/handheld) computing or mobile devices for e-learning. As a result, the study highlighted the interconnectivity between e-learning and m-learning (Motiwalla, 2007).

Based on the foregoing there exists a relationship between m-learning and e-learning. Many studies have been performed to examine the intricate dynamics of both methods of learning. Therefore, this study seeks to present a concise overview of these studies based on a review of literature from the last 15 years available in the web of science data based as described in the next section of the paper. It is envisaged that the review of the literature will provide the reader will comprehensive insights into the theories, models, concepts, features, merits and demerits of the various learning technologies. Lastly, it will attempt to map out the developmental trajectory of the concepts over the past 15 years and prospects for pedagogical systems and technologies for efficient education and training in the future.

Research Methodology

The developmental trajectory and transition path of e-learning and m-learning were analysed based on searching for publications. The key words e-learning and m-learning were inserted into the database of Thomson Reuters Web of Science (WoS) operated by Clarivate Analytics Inc. Next, the search criteria were narrowed to the publications published and indexed in the data from 2004 to 2018. Figures 2 and 3 present a bar chart and a summary of the yearly trajectory of the concepts of e-learning and m-learning based on the search results in the WoS database.

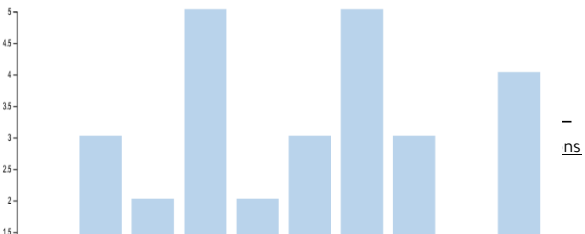

Figure 2: Trajectory of Developments in e-learning and m-learning

The results show that interest in e-learning and m-learning has fluctuated over the years with the most number of publications i.e. 4, 5, and 5 observed in 2008, 2012, and 2015, respectively. These account for 10.53% (2004), 13.16% (2012) and 13.16% (2015) of the publications retrieved and analysed from the WoS database.

Based on the search criteria, a total of thirty-eight (38) of most cited papers on the subjects were selected from the search results for further analysis of developments in the concepts. This was comprised of 26 proceedings papers (68.42%), 9 scientific articles (23.68%), 2 book reviews (5.26%), 1 meeting abstract (2.63%) and 1 book chapter (2.63%) (also categorised as a book review) making a total of 38 records.

The search results also showed that e-learning and m-learning are largely categorised into the following web of science categories; educational research, computer science, engineering. Figure 4 presents a treemap pictorial summary of the search results based on the web of science (WoS) categories for e-learning and m-learning.

Select	Field: Publication Years	Record Count	% of 38	Bar Chart
	2018	1	2.632 %	
	2017	3	7.895 %	
	2016	2	5.263 %	
	2015	5	13.158 %	
	2014	2	5.263 %	
	2013	3	7.895 %	
	2012	5	13.158 %	
	2011	3	7.895 %	
	2009	1	2.632 %	
	2008	4	10.526 %	
	2007	3	7.895 %	
	2006	3	7.895 %	
	2004	3	7.895 %	

Figure 3: Summary of Publication Data on e-learning and m-learning from 2004-2018.

Figure 4: WoS Categorization for e-learning and m-learning from 2004 to 2018

The results demonstrate that e-learning and m-learning are interdisciplinary concepts that span the areas of education, computer science, engineering, telecommunications, information and library science. Others include; communication, social studies, chemistry, cybernetics, economics, environmental studies, medicine among other fields.

Figure 5 presents data on the contributions of each field in the web of science categories, record count, and percentage contributed by the 38 most cited papers obtained from the search results. It is important to note that some of the papers resulting from the search are categorised into one or more fields, hence the summation of the percentage share may exceed 100% as can be surmised from Figure 5.

Select	Field: Web of Science Categories	Record Count	% of 38	Bar Chart
	EDUCATION EDUCATIONAL RESEARCH	22	57.895 %	
	COMPUTER SCIENCE INFORMATION SYSTEMS	9	23.684 %	
	COMPUTER SCIENCE INTERDISCIPLINARY APPLICATIONS	7	18.421 %	
	COMPUTER SCIENCE THEORY METHODS	5	13.158 %	
	EDUCATION SCIENTIFIC DISCIPLINES	5	13.158 %	
	ENGINEERING ELECTRICAL ELECTRONIC	5	13.158 %	
	TELECOMMUNICATIONS	4	10.526 %	
	COMPUTER SCIENCE ARTIFICIAL INTELLIGENCE	3	7.895 %	
	COMPUTER SCIENCE HARDWARE ARCHITECTURE	2	5.263 %	
	ENGINEERING MULTIDISCIPLINARY	2	5.263 %	
	INFORMATION SCIENCE LIBRARY SCIENCE	2	5.263 %	
	SOCIAL ISSUES	2	5.263 %	
	AUTOMATION CONTROL SYSTEMS	1	2.632 %	
	CHEMISTRY MULTIDISCIPLINARY	1	2.632 %	
	COMMUNICATION	1	2.632 %	
	COMPUTER SCIENCE CYBERNETICS	1	2.632 %	

Figure 5: WoS Categorisation, Record Counts and Contributions

The findings indicate that educational research, computer science, and engineering accounted for 57.9%, 23.7% and 13.2% of the papers obtained from the search. In addition, the findings demonstrate that computers, information systems, and computer science are critical to the acquisition, analysis, and consumption of education materials and learning resources for m-learning and e-learning. In general, the conclusions revealed that e-learning and m-learning play a significant role in current pedagogical systems thereby ensuring that computer and ICT technologies are used to efficiently deliver educational materials and learning resources. In addition, the multidisciplinary and overlapping nature of the concepts across many disciplines is indicative of the importance of e-learning and m-learning to education and training. Section 3 will present an overview of the most cited papers retrieved from the WoS search.

1. Results and Discussion

Table 1 presents the critical findings, summary and conclusions of the top 20 most cited of the publications retrieved from the WoS search on e-learning and m-learning in literature. Based on the results, the retrieved publications on e-learning and m-learning garnered a total of 153 citations over the years. Figures 6 and 7 present data on the citations on e-learning and m-learning from 2004 to 2018.

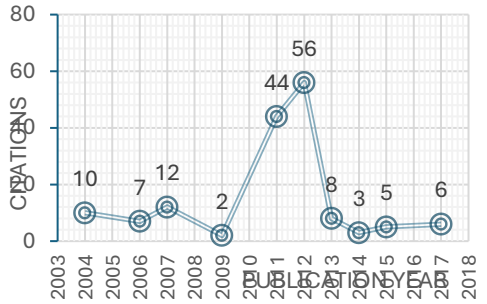

Figure 6: Citation Report for e-learning and m-learning

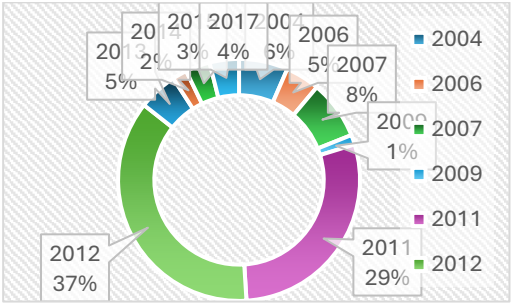

Figure 7: Share of Publications based on Year Published.

Table 1: Summary of the most cited publications on e-learning and m-learning

SN	References Cited	Title of Publication	Publication Type	Number of Citations	Year
1	Korucu *et al.* (2011)	Differences between m-learning (mobile learning) and e-learning, basic terminology and usage of m-learning in education.	Conference paper	44	2011
2	Nedungadi and Raman (2012)	A new approach to personalization: integrating e-learning and m-learning.	Journal Paper	33	2012
3	Ozuorcun and Tabak (2012)	Is M-learning versus E-learning or are	Conference paper	20	2012

		they supporting each other?			
4	Kambourakis *et al.* (2007)	A PKI approach for deploying modern secure distributed e-learning and m-learning environments.	Journal Paper	12	2007
5	Kambourakis *et al.* (2004)	Introducing attribute certificates to secure distributed e-learning or m-learning services.	Conference paper	8	2004
6	Joo-Nagata *et al.* (2017)	Augmented reality and pedestrian navigation through its implementation in m-learning and e-learning: Evaluation of an educational program in Chile.	Journal Paper	6	2017
7	Kim *et al.* (2013)	A development of learning widget on m-learning and e-learning environments.	Journal Paper	6	2013
8	McArdle *et al.* (2006)	3D collaborative virtual environments for e-learning and m-learning.	Conference paper	4	2006
9	Georgiev *et al.* (2006)	Transitioning from e-learning to m-learning: Present issues and future challenges.	Conference paper	3	2006
10	Abramson *et al.* (2015)	An Examination of the prior use of e-learning within an extended technology acceptance model and the factors that influence the behavioural intention of users to use m-learning.	Journal Paper	2	2015

11	Andreicheva and Latypov (2015)	Design Of E-Learning System: M-Learning Component.	Conference paper	2	2014
12	Merayo *et al.* (2015)	M-learning and e-learning interactive applications to enhance the teaching-learning process in optical communications courses.	Journal Paper	2	2015
13	Kubac *et al.* (2013)	M-learning as the next level of e-learning.	Conference paper	2	2013
14	Martin *et al.* (2009)	Middleware for the development of context-aware applications inside m-Learning: Connecting e-learning to the mobile world.	Conference paper	2	2009
15	Trifonova *et al.* (2004)	Mobile ELDIT: Transition from an e-learning to an m-learning system.	Conference paper	2	2004
16	Kopecky and Hejsek (2015)	Mobile touch devices as an effective tool of m-learning and e-learning.	Conference paper	1	2015
17	Henno *et al.* (2014)	From Learning to E-learning to M-learning to C-learning to	Conference paper	1	2014
18	Jennings (2012)	Combining E-Learning and M-Learning: New Applications of Blended Educational Resources.	Journal Paper	1	2012
19	Chorfi *et al.* (2012)	From e-Learning to m-Learning: Context-Aware CBR System	Conference paper	1	2012
20	Cloete (2012)	Combining E-learning and M-learning: New Applications of Blended Educational Resources.	Journal Paper	1	2012

The results in Figure 5 and 6 indicate that the highest number of citations (100) was in 2011 and 2012 based on 3 and 5 publications, respectively. However, the citations decreased from the peak 56 in 2012 to 8 in 2013 and 6 in 2017. This suggests that interest in the fields of e-learning and m-learning may be thawing, although it is unclear why this is occurring. Furthermore, Figure 7 shows that the highest share of citations based on the year were 37% and 29% in 2012 and 2011, respectively, whereas the lowest can be observed in 2009 with 1%. Next, the findings of the top 20 cited publications in the study will be highlighted in detail.

Korucu *et al.* (2011) examined the differences between m-learning and e-learning in education. In addition, the study presented and highlighted the basic terminologies, prospects and challenges of m-learning. The findings indicated that internet access and usage is a major barrier for m-learning and e-learning. It highlighted that availability portability, and versatility of mobile devices has encouraged the adoption of m-learning. Nedungadi and Raman (2012) presented a novel approach and insights for the personalization and integration of e-learning and m-learning. The authors opined that majority of the personalized systems for teaching and learning are targeted at e-learning and m-learning. In addition, the study presented a novel cloud-based adaptive learning systems that integrate a formative assessment process with mobile devices for e-learning. The system called the Adaptive Learning and Assessment System (ALAS) is based on the Knowledge Space Theory model. According to the study, the system can potentially provide teachers with real-time feedback on personal or groups of learners. Ozuorcun and Tabak (2012) examined the commonplace questions about the relationship between m-learning and e-learning. In addition, the study identified and highlighted the effects of an ever-changing society on education and learning in schools around the globe. The findings indicated that solutions to the problems of e-learning and m-learning can be addressed by proffering answers to the numerous questions such as, "Is m-learning supporting e-learning, or is m-learning in opposition to e-learning?" Georgiev *et al.* (2006) examined the transition process from e-learning to m-learning along with the current and future challenges. The findings showed that m-learning is a potential method for teaching and learning in pedagogical environments. The findings revealed that the key challenges impacting on the transition from e-learning to m-learning can be categorized into pedagogical, technical and developmental. More importantly, the study demonstrated that m-learning is novel technology that emanates from e-learning although with more prospects for students, educators and developers of learning content.

The studies by Kambourakis *et al.* (2004); Kambourakis *et al.* (2007) examined proposed a novel PKI (Public Key Infrastructure) technique for deploying attribute certificates (ACS) to secure distributed e-learning or m-learning services. The proposed PKI and ACS can potentially provide infrastructure to provide permission and verification services that enhance the reciprocal trust between learners and the service providers. The findings demonstrated that issuing ACs is feasible at the same time as concurrently providing flexible and accessible services to learners. Similarly, Kim *et al.* (2013) developed and proposed a novel learning widget for e-learning and m-learning

environments. The simple, small sized application was aimed at supporting contents for mobile phones users. The findings indicated that widget is an effective learning tool with enhanced usability, usefulness and effectiveness for m-learning and e-learning. However, the authors reported some interface problems while conducting pilot tests using students and teachers based on analysis using technology acceptance model (TAM).

The study by McArdle *et al.* (2006) proposed a 3D collaborative virtual environments for e-learning and m-learning. The aim of the study was to address two key failings of current web-based learning systems namely; student motivation and collaboration. As a result, the authors devised an e-learning solution called the CLEV-R (Collaborative Learning Environment with Virtual Reality). This multi-user based web solution allows students to interact and collaborate with one another through 3D environments. The authors aim to enhance the popularity of CLE and CLEV-R type technologies for future education and training.

Furthermore, Andreicheva and Latypov (2015) presented the design of an e-learning system integrated with a component or interface for m-learning. Based on the design, three important components or applications were incorporated namely; desktop, mobile, and web. More importantly, the proposed system was developed to enhance the efficiency of learning along with improving homework assessment, statistical analysis, and feedback. Similarly, Merayo *et al.* (2015) proposed interactive m-learning and e-learning applications to improve the teaching and learning process in courses for optical communications. The study discoursed the importance and flexibility of telematics and interactive tools in educational development. It also highlighted the importance of m-learning as an effective technique for transforming and strengthening traditional strategies for training and learning. Moreover, the study observed that the use of mobile devices can also improve the interaction between students and teachers; enhance the teacher work productivity and student motivation to learn. The study also noted that power software and interactive tools such as Android applications can increase autonomy and skills acquisition capacity of students. Lastly, the study demonstrated that development and integration have numerous merits ranging from speed, convenience, and quality of educational delivery. Other studies by Trifonova *et al.* (2004), Kopecky and Hejsek (2015), Henno *et al.* (2014), Jennings (2012), Chorfi *et al.* (2012) and Cloete (2012) also developed various applications, software, and integrated systems for m-learning and e-learning platforms. Some of which include Mobile ELDIT Trifonova *et al.* (2004), mobile touch devices Kopecky and Hejsek (2015), Context-Aware CBR system Chorfi *et al.* (2012) along with blended educational resources Cloete (2012).

2. Conclusions

The paper reviewed the current literature on the teaching and learning concepts of e-learning and m-learning. As a result, the current developments, prospects and challenges were identified, highlighted and examined in detail. The methodology analyses of past and current publications from 2004 to 2022 based on the data Web of Science (WoS) databases of Thomson Reuters. Subsequently, the thirty-eight (38) most cited papers comprising conference papers, scientific articles and monographs in

the field were selected for further analysis. The findings revealed that m-learning was developed from e-learning due to the need for speedy, cost-effective and on-the-go resources for learning. As a result, the concept has evolved over the years due to the development, growth, and widespread availability of the world wide web or the internet around the globe. Other developments have included the development of many interactive tools, software and applications such as Mobile ELDIT, mobile touch devices, Context-Aware CBR system and Blended Educational Resources. In addition, other researchers have developed key computer structures and security features to improve the security of m-learning and e-learning resources. These include public key infrastructure (PKI), attribute certificates (ACS) to secure distributed e-learning or m-learning services. Other innovations such as the collaborative learning environment with virtual reality (CLEV-R) have been aimed at enhancing the interaction and collaboration of students and teachers alike through 3D educational environments. Over time, the concept of m-learning and e-learning have gained popularity with applications spanning major fields and disciplines such as educational research, computer science, engineering, telecommunications, information and library science, and social issues. According to the WoS database, the top three (3) disciplines are; educational research, computer science, engineering, which account for 57.9%, 23.7% and 13.2% of the materials analysed, respectively. Generally, the findings revealed that the twin concepts of e-learning and m-learning will play a significant role in the future of pedagogical systems and technologies for efficient delivery of education, materials and learning resources.

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