Adoption of Mobile-based Learning to Promote Cognitive Engagement among Girls in Secondary Schools in Kenya

Jean Murigu
University
Course
Professor
Date
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Introduction

Background

Mobile-based learning is increasingly gaining roots in developing countries. Many African countries have gradually integrated mobile-based learning into their education system in the last five years. Higher learning education institutions, especially Universities and Colleges, were the first to adopt mobile-based learning as part of their instructional methods. However, the increasing challenges facing the provision of basic education in African countries have triggered unprecedented attempts to integrate mobile-based learning into primary and secondary levels of education. E-Learning Africa (2020) explains that the education sector in many African countries struggles with inadequate resources, including insufficient learning classrooms, a shortage of teachers and inadequate learning resources. Besides, the basic level education system in developing countries has recently experienced major unplanned disruptions, including teacher strikes and the closure of schools due to the manage Covid-19 pandemic (E-Learning Africa, 2020). In attempts to address these challenges, the education stakeholders embrace mobile-based learning technologies. While the education stakeholders are focusing on developing educational policies that encourage the adoption of mobile-based learning to promote equal access to basic education, the developers of the mobile-based learning applications have a responsibility to ensure they design and develop educational applications that promote effective learning among all learners.

In Kenya, the Kenya Institute of Curriculum Development (KICD) is making significant strides in promoting the adoption of mobile-based learning at the basic education level. Recently, the KICD released a set of standards for evaluation and approval of mobile educational applications intended for use at the basic educational level, including the Early Childhood Development Education (ECDE), Primary and Secondary School Level (KICD, 2021). However, the KICD’s standards for educational mobile applications focus on the quality of the applications, especially the application’s versatility, security of the data, easiness of language and reliability (Chee et al., 2018). While the versatility, stability and reliability of the educational mobile applications are critical to promoting equal access to basic education for all learners in Kenya, there is a need for consideration of information load and the design of the multimedia content to avoid cognitive overload and cause adverse impact to effectiveness in learning (Fu et al., 2018; Curum & Khedo, 2021). Eneje (2022) explains that after developing an educational mobile application, the tool requires further adaptation to pedagogy and instructional design to promote effective learning. Eschenbrenner and Nah (2019) concur that inadequate content adaptation with the learners’ context information complicates understanding and reduces the learning experience. In this regard, the KICD needs to determine the cognitive load on learners for the different levels of education based on the information flow presented to the learners.

Typically, the developers of the mobile-based learning applications in the setting of the developing countries focus on the efficiency of the application and ignore the adaptability of the content. Bacca-Acosta and Avila-Garzon (2021) argue that the working memory part of the human cognitive architecture is limited to handling a definite number of processes at a time. It implies that educational mobile-based applications with a limited design of learning elements and instructional methods can lead to an overload of the learners’ working memory (Dolawattha et al., 2019). In this regard, this research aims to demonstrate that the KICD needs to develop standards that can guide the developers of the educational mobile-based applications in adapting the designs of the applications to promote effective learning through consideration of the cognitive needs of different learners.

This paper reviews the instructional design and cognitive theories appropriate to educational mobile learning applications among secondary school level students in Kenya. The paper explores various instructional design principles and learning theories that can support effective learning through mobile-based learning applications. First, the paper explores the concept of mobile learning. Also, the paper explores the cognitive load principles that are appropriate for mobile learning, and their impact on mobile-based learning. Besides, it identifies the instructional design principles suitable for effective cognitive load management in educational mobile-based applications.

Research Methodology

Many curriculum development agencies across Africa have kick-started the adoption of mobile-based learning among institutions offering basic education levels. In Kenya, the KICD has released a set of standards guiding developers on the desired educational mobile-based applications. As in other cases worldwide, the KICD expects to promote effective learning and increase access to basic education through mobile-based learning applications. There is a need to consider the potential of cognitive-based theories in enhancing mobile learners' concentration span and motivation, especially learners from vulnerable populations, including the girl child in Kenya. Despite significant research on cognitive load theories in mobile-based learning, the existing literature lacks
consolidated information on the cognitive load theories, which can help developers of the mobile-based learning applications to have a clear understanding of the dynamics of cognitive load and develop appropriate interventions to promote efficient learning through mobile-based learning.

The research methodology derived for this paper is based on a review of the cognitive load theories suitable for mobile-based learning. The review utilizes the Kitchenham method. The Kitchenham method entails setting and narrowing research questions using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) technique (Zhang & Neitzel, 2021). Also, PRISMA involves identifying and evaluating different pieces of evidence to answer the research question.

Planning the Review
This paper explores existing research on the effectiveness of cognitive load theory in mobile-based learning. The paper develops a comparative schema for adopting cognitive load theory and explores adaptation of instructional design for management of cognitive load management in educational mobile learning applications.

Research questions
The paper addresses the following research questions:
1. What are the fundamental learning theories?
2. Determine appropriate instructional design principles for adaptation of educational mobile-based applications?
3. Which is the best practice to manage cognitive load and pedagogy strategies to promote effective learning in mobile-based learning?

Conducting the review
The searching process
The search process involved using the Google Scholar search engine in identification of the most current and relevant cognitive load theories, instructional design principles and their impact on mobile-based learning.

Inclusion and exclusion criteria
The search considered studies not older than five years. The researcher queried various keywords, including cognitive load, cognitive load theories, mobile-based learning, self-regulated learning, instructional design principles, learning theories and adapting cognitive load theories. The search excluded sources focusing on irrelevant topics, including cyber security in learning, cognitive load theories in the classroom setting, and health-related articles on the impact of remote learning on cognitive function.

Search
The keyword search in Google Scholar led to 40 articles related to the research. The researcher conducted a manual screening while utilizing the inclusion and exclusion criteria leading to the selection of 20 articles for the research paper.

Mobile learning
Learners can access learning materials through different platforms. Mobile devices can be used to access learning materials even for the learners who are utilizing the traditional learning setups. According to (İbili, 2019), the greatest advantage of accessing learning materials through mobile is in its ease of mobility and portability. Learners and tutors can interact at any moment and this leads to a better learning experience. Moreover, while using mobile devices, the learners can utilize online and offline learning at any time or in any place as they can access the learning materials in real-time (Cakmak, 2019). It is easy to collect and process data on mobile phones because they are equipped with a range of sensors. There has been immense technological growth and this has led to the evolution and improvement of mobile gadgets as compared to the past (Curum & Khedo, 2021). The rise of Smartphone has enhanced learning because learners can easily access the learning materials remotely and they can easily communicate with their tutors or with other learners through various social media platforms.

The advanced technological techniques have created an enabling environment that allows the generation of adaptive learning materials. Mobile device learning has introduced a new learning paradigm that encourages gaining knowledge in a dynamic and changing environment (İbili, 2019). Cakmak (2019) explains that certain learning theories have been postulated to explain the new mobile learning technique. The first theory is the cognitive theory which focuses on the senses of a learner while the second theory is the constructivism theory which takes into consideration the learner’s prior knowledge. The third theory, the behaviorism theory, looks into the moods and emotions or the state of mind of the learner. Despite more attention given to the behaviorism learning method, there is little attention to the emotions of a learner and how they could affect their mobile learning (Cakmak, 2019). When the environmental and biological concepts that affect the motivation of a learner are taken into consideration, it is easier to understand the impact of their emotions on learning (Curum & Khedo, 2021). Therefore, it is essential to identify the various factors that affect the emotional well-being of a learner as they have a direct impact on their learning patterns.
Further, instructional design principles also influence the progress of mobile learning. Instructors should avoid using poor instructional designs as they cause confusion and frustration to the learners. Curum and Khedo (2021) argue that there is a huge difference between browsing through the information on small mobile phone screens and utilizing the larger laptop screens. Therefore, the instructors or tutors should always take into consideration the size of the phone screens, their compatibility, and the sensors available while preparing the learning materials. When instructional designs are in line with the mobile gadgets, a balance between the cognitive strains and efficient learning in better surroundings is achieved (Cakmak, 2019). The learning materials should be modified in ways that ensure their visibility is compatible with a wide range of devices.

**Self Regulated Learning (SRL)**

When learners plan and set their objectives and also come up with strategies to accomplish specific academic goals it is called self-regulated learning. Learners have been utilizing their mobile phones to connect to various educational applications at their convenience and this enables them to keep tabs on their activity-based performance (Taranto & Buchanan, 2020). The mobile-assisted systems are equipped with special features like learning analytics that has contextual data which is used in monitoring and guiding individual learning (Taranto & Buchanan, 2020). The individual data is available in online and offline modes and the learners can assess their levels of self-awareness, organization, and motivation which guide them to understand how they are performing in their academic work (Taranto & Buchanan, 2020). The learners also utilize the social media platforms in the self-regulated learning model, especially through social networks such as Facebook and Twitter that create engaging platforms where learners share and exchange their learning materials in real-time (Taranto & Buchanan, 2020). These chat forums create an interaction for the exchange of knowledge and it is convenient for most learners as they are regularly connected to the different social media sites (Curum & Khedo, 2021). Self-regulated learning can be very interesting for learners as it is done at their pace and they can utilize interactive social media and online accounts to receive and exchange knowledge.

**Cognitive Load Principles for Mobile Learning**

Learners exert different strains on their mental abilities to understand different concepts and it is referred to as the cognitive load. A learner has to utilize their cognitive abilities to gain meaningful learning (Shadiev et al, 2018). According to the cognitive load theory, the working memory capacity of learners should be explored to ascertain their learning abilities. This theory is categorized into germane, extraneous, and intrinsic loads. The intrinsic cognitive load entails the frontal information which deals with the load of information that a learner can handle while learning is taking place (Curum & Khedo, 2021). On the other hand, the germane load determines the level of the conscious mind of a learner that helps them remember the content of the information that they were taught. The germane load is also responsible for the growth and transfer of knowledge because when learners recall what they learned, they can share it with other students (Shadiev et al, 2018). Then, the extraneous load is responsible for the undesirable learning features that cause stress to the minds and mental processes of learners (Curum & Khedo, 2021). One of the things that can cause mental strains due to the increased cognitive burden is the use of inappropriate instructional designs.

The cognitive load theory calls for reduction of extraneous load through modification of learning activities that can make a task intrinsically complex. Conversely, a decline in the extraneous load leads to the balancing of the germane load (Cakmak, 2019). Moreover, the repetitive learning concepts and other confusing statements should be limited to the learning materials displayed well. The cognitive load of most learners is not used to the mobile learning system and the most appropriate way is by trying to use more effort to understand the learning materials on phones which might be complex.

Notably, mobile phone developers have been using different foreign languages when developing learning apps as it improves the cognitive load of the learners (Bernacki, Crompton, & Greene, 2020). However, these efforts from mobile phone and learning application developers are not comprehensive and more efforts should be put forward to make learning easier for students. The best ways of cognitive management in the mobile phone learning systems can be achieved if features that increase the learning capabilities and levels of concentration or those that improve the attitudes of the learners can be installed on the phones (Shadiev et al, 2018). Therefore, more adaptations or modifications should be introduced to the phones to enhance the cognitive management of learners who use their mobiles to study.

**Cognitive Load Theories**

Since one of the major factors that contribute to higher cognitive burdens among mobile phone learners is the use of inappropriate learning materials, several techniques can be utilized to reduce this burden. Ozer and Kılıç (2018) explain that learners can utilize their past knowledge in different contexts and reduce their cognitive burden through the help of their mobile phone learning systems (Ozer, & Kılıç, 2018). Some of the other theories that
expound on the cognitive processes and how they affect mobile learning include the psychological learning process and the cognitive information processing theory.

The psychological learning process theory holds that learners come from diverse social backgrounds that give them varying experiences. These different experiences influence the perceptions, emotions, attitudes, problem-solving, and information processing abilities of the learners (Bernacki et al., 2020). Therefore, these differences make students have varying learning styles that they adapt depending on their backgrounds and experiences. According to the psychological learning method, the mobile phone learning systems should consider incorporating fun learning techniques that are easier to link their past skills and experiences (Buchner et al., 2022). Such an approach would create an enjoyable method for the learners to transfer their knowledge.

On the other hand, the cognitive information processing theory pays attention to how the current surroundings affect the grasping or storage of information in the memory. This theory looks into how the sensory memory handles the information collected from the vision and hearing senses (Sampson et al., 2020). A learner relies on a combination of past memories and experiences to gain meaningful learning opportunities. There are instances when learners utilize selective attention where they focus on the crucial or relevant information and ignore the extraneous information that would increase their cognitive burden. The theory also holds that the learning elements should be organized into units that increase the working memory of the learners that utilize the mobile learning systems (Suartama et al., 2020). There is a likelihood of losing important learning details when the learning materials are getting sub-divided to highlight the ones considered important. The best way to avoid the loss of important data when creating learning materials for mobile phone learners is to utilize the flowcharts, concept trees, hierarchy diagrams, and bar graphs to reinforce the summarized information (Osborn et al., 2018). Another strategy that can be utilized is using multiple-choice questions or self-assessment tests that enable the learners to remember the important details of the topics covered.

Impact of Cognitive Load on Learning

The Split Attention Principle

When learners utilize small screen mobile phones, it is hard to capture their attention. Moreover, handling the learning materials on the small screens increases the cognitive burden of the learners and it also has a negative impact on their learning experiences (Chang et al., 2021). Fortunately, this challenge can be handled through the split attention principle that argues that the learning abilities of people are enhanced if the information is presented in more than one form. Therefore, the learning materials should be presented in texts, pictures, animations, videos, or audio. The synchronization of the instructional learning materials for use on mobile phone devices allows the learners to understand concepts faster (Demir & Akpinar, 2018). However, the different forms of learning materials should be used in moderation as incorporating many formats would be confusing and lead to a shift in attention causing low performance.

Instructional Design Principles for Cognitive Load Management

Mainly, the instructional designs that instructors incorporate when preparing the learning materials lead to a balanced cognitive burden; thus, promoting effective learning. The instructional designs used on mobile phone learning materials should create ease of learning for the students (Jansen et al., 2020). The success of remote learning through mobile phones gets successful depending on the instructional design of the learning materials prepared by the tutors (Jansen et al., 2020). Shadiev et al. (2018) adds that for the learning materials being presented to fit the model of different mobile device interfaces, the tutors should have sufficient knowledge about the operation of the devices. Some of the features that should be taken into consideration are the layouts of the phones, their screen sizes, their compatibility with different gadgets, and their bandwidth abilities.

The multi-media support functions of the phones should also support the transformation of the learning materials to capture different interactive sessions. After taking into consideration the environment where mobile device learning will take place, the learning activities and materials should be modified to fit the gadgets (Shadiev et al, 2018). This type of modification is referred to as the integrated presentation which enables learners to pay more attention to the important information and at the same time maximize their cognitive capacities (Jansen et al., 2020). There are different instructional design models that have been created to fit the mobile device learning materials. These models are designed with great consideration to the cognitive load principles to help gain the most from any learning activity.

Instructional Design Techniques

This section describes two main instructional design techniques widely used in developing content for mobile-based learning. The two models: The ADDIE Model and Mobile Human-Computer Interaction Model are analyzed using the cognitive load principles and theories to determine the effectiveness of mobile-based learning.
The ADDIE Model

Typically, the ADDIE Model entails five main stages: analysis, design, development, implementation and evaluation, to address the designing of mobile-based learning. The ADDIE Model provides instructional designers with a comprehensive guideline for systematically developing efficient learning content (Suartama, 2019). The model classifies the instructional goals and objectives that a designer should establish to optimize learning. It identifies parameters including the learning environment and prior knowledge and skills in evaluating pedagogical levels. Grant (2019) argues that the ADDIE Model helps identify the knowledge gap and design a mobile-based learning system that aligns with relevant learning objectives suitable to cognitive load theories. Also, Wijaya et al. (2021) explain that the ADDIE Model offers a training plan which gives additional instruction for effective conditions for self-management. Besides, the model has a responsive ability that adapts to several screen sizes for mobile phones. Thus, the ADDIE Model offers integrated learning, making it popular in e-learning and appropriate for mobile-based learning.

Mobile Human-Computer Interaction

Mobile Human-Computer Interaction Model (MCHI) focuses on the learner's behavior and interactions with educational mobile-based applications. The model advocates considering a learner's physiological conditions when creating an educational mobile-based application (Suartama, 2019). The MCHI model suggests developing a personalized educational, mobile-based application rather than one generalized design that adopts a fit-all approach. Kaptelinin and Nardi (2018) add that MCHI requires instructional designers to consider and integrate the learner's motivation and level of engagement with the core of the educational mobile-based applications. Thus, MCHI calls for instructional designers to evaluate the versatility of the interfaces of their educational mobile applications and adopt them to relevant design principles.

Discussions

Developers of educational mobile-based learning applications experience a challenge in adapting learning contents to suitable instructional design. The above analysis reveals that different instructional designs require appropriate adaptive features to enhance learner’s accessibility and usability. However, learners are likely to be presented with learning materials that are inappropriate for their learning style, especially when the instructional designers fail to apply relevant cognitive theories. As a result, the learner’s working memory is constrained and can lead to mental stress. Notably, common instructional design models including the ADDE Model and the Mobile Human-Computer Interaction Model provide developers with generalized mobile-learning interfaces, which hinder customization of learning activities to suit learner’s needs. In this regard, educational mobile-based applications should include appropriate learning effects for cognitive loads to allow learners have adequate space depending on the prior knowledge and preferences which can encourage them to establish a personalized and self-regulated learning setting. Instruction designs should incorporate context-aware elements for management of cognitive concerns in mobile-based learning applications. Incorporating cognitive theories in mobile-based learning applications can disambiguate dissemination of learning resources and promote learner’s understanding of the content. Still, advanced adaptation can incorporate the learner’s context, implying a possibility of merging the learner’s context with cognitive theories and instructional design principles to develop adaptive and customized content. Thus, the objective of developing adaptive strategies is to enhance the flow of learning through customized mobile-based learning experiences. Customized mobile-based learning can offer learners with choices to adapt the content their prior knowledge and learning experiences to develop a predictable learning sequence.

Conclusion

Designing an efficient mobile-based learning application, especially one that is easily accessible and customized to student’s context and cognitive abilities is a daunting task. Currently, educational mobile-based applications are not yet adaptable to the dynamic capabilities of the sophisticated Smartphone that users in both developed and developing countries use. Besides, there is limited research on management of cognitive load and adaptation to relevant instructional design principles. However, it is evident that offering learners with several options through adaptation of mobile-based learning content to relevant instructional design principles can promote effective learning. Despite the paper not addressing incorporations of cognitive theories and instructional design principles in animations, there is need to focus on establishing mobile-based learning guidelines on adaptation of cognitive theories and instructional design principles in animations for effective learning. The educational stakeholders, especially the KICD in Kenya, should give more focus on promoting remote learning strategies and adapting the learning content to cognitive theories and instructional design principles to enable learners benefit from constructive learning.
References


