A User-centric Design and Pedagogical-based Approach for Mobile Learning

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***Abstract*—The adoption of various learning technologies in education has gained momentum in the last couple of decades due to: (i) their ability to meet stakeholders' requirements and (ii) offering a wide variety of services that are accessible from different platforms, such as mobile learning and online learning. Despite the success of mobile learning, certain limitations and shortcomings have been reported in literature, such as the insufficient design and limited support provided to stakeholders. This paper focuses on reviewing the studies relating to m-learning application for identifying the issues and challenges limiting its adoption, and proposes a pedagogy-informed and user-centric design framework for mobile learning artifacts which would address the issues identified. The findings from the review revealed that user-centric issues, such as privacy, security, usability, learnability, and socio-cultural aspects (including adaptability of the application, sustainability, integration with pedagogical approaches) are the main factors affecting users in adopting an m-learning approach. Considering these issues, a user-centric framework integrated with socio-cultural aspects, design and technology attributes is proposed.**

Keywords- m-learning; pedagogy; user-centric design; user-centric methodology; software engineering; software development methodology.

I. INTRODUCTION

The rapid developments across the Internet and telecommunication technologies have paved the way for developing and adopting innovative and efficient methods of learning in many fields. Various innovative technologies such as mobile technologies, Internet and communication technologies have been applied in educational sector. This has enriched teaching and learning processes, and consequently has reflected on learning flexibility, effectiveness and efficiency. It is estimated that 47% of the worldwide organizations are using mobile devices in their training programs, as it enhances the user engagement in learning and helps in knowledge retention [1]. The global market for mobile learning, henceforth m-learning, is expected to cross $12.2 billion in 2018 as it is advancing at a fast rate [2]. Accordingly, a rapid increase in the mobile workforce was observed in the recent years, which is expected to double or triple its size in 2018 [3]. Since stakeholders expect answers at their fingertips, the real-time access to information on mobile devices boosts the adoption of m-learning [4]. In addition, the number of mobile devices would increase to three on average by the end of 2018 [5]. Furthermore, the amount of time spent on using mobile devices is significantly increasing in the recent years as mobile devices become more reliable in accessing various types of information [6].

Though there is a rapid increase in the m-learning approaches, there have been various challenges identified with it. *First*, the traditional teaching can have one to one access, where the learner's abilities are assessed and accordingly the teaching process is modified to suit the learner's abilities [7], where it is not clear how this could happen via m-learning. *Second*, the insufficient support provided via m-learning platforms across various contexts [7]. *Third*, the impact of design on effective learning, where design in this context refers to system design rather than learning content design. *Fourth*, the difference in mobile usage habits and attitudes across the regions [8]. Other challenges identified include security, accessibility, contents accuracy, adaptability, etc. [9]. As stated above, most of these issues are associated with theory and practice of teaching, and user-centered factors.

Therefore, this paper is an attempt to understand how a pedagogy-informed and user-centric design methodology could be useful for m-learning. The rest of this paper is organized as follows. Section II reviews the related work in m-learning and pedagogy. Section III introduces the user-centric design framework methodology for developing m-learning systems. Section IV addresses the user-centric design methodology. Section VI concludes the paper and suggests future research directions.

II. M-LEARNING AND PEDAGOGY

M-Learning is the process of learning across multiple contexts using various social interactive features on the mobile devices [10]. Learning in educational field varies from one region to another depending on the socio-cultural aspects. Integrating socio-cultural and methods underpinning them (i.e., pedagogy) into mobile technological environments is one of the major challenges in m-learning. This aspect has been the focus of research in many studies. In this context pedagogy refers to theory, methods and practices of teaching and learning, which can include various approaches. Therefore, the concept of 'one-size-fits-all' would be an impractical approach in developing m-learning platforms [11]. Consequently, integrating pedagogical theories and models with technology is inevitable to design effective and efficient m-learning platforms [12].

In addition to these concerns, it is also very important to consider the user-centric aspects such as attitudes, behavior, usability, learnability etc. in developing m-learning

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platforms. Literature studies [13] investigate the attitudes of students and educators in the Arab region towards m-learning identified significant difference in students' attitudes towards m-learning, while positive attitudes were observed among the educators. Another recent study by Chung et al. [14] identified that the students' behavioral intentions had high positive correlations with mobile devices' compatibility, self-efficacy, perceived ease of use; the majority of the students showed positive approach towards adopting m-learning.

However, Khan et al. [15] reveals the need to increase awareness, training, and motivation for adopting m-learning approach among students and educators. Moreover, students in secondary school have positive perceptions about m-learning but their m-learning adequacy levels are identified as not sufficient enough to put it in to practice. The above-mentioned studies reveal that m-learning platform features and usability aspects could influence the attitude towards their adoption. Likewise, the adoption of m-learning would be dependent on various user-centric attributes, such as level of education, age, awareness etc. Abachi and Muhammad [16] investigate the impact of m-learning on educators and learners, and found that great enthusiasm was shown by the users regarding augmented reality-based m-learning platforms. Though, the users favored the adoption of m-learning, they have expressed concerns in relation to security and coverage (completeness, accuracy).

Another important perspective of evaluation is to assess how the mobile platform adaptation could influence the learning process. M-learning has a dynamic scope as the users would be constantly moving and the context from which they learn can be changing. Therefore, adaptation according to these changes by the mobile platforms is essential for providing effective and dynamic learning process. Nevertheless, Garcia-Cabot et al. [17] finds that mobile adaptation had limited impact on the learning process, since students learn in similar contexts despite the fact that they use different ways to access learning contents.

On one hand, technological aspects of m-learning platforms design need further investigation in order to embed the best teaching practices into innovative m-learning. Such technological aspects could influence various features and characteristics such as usability, learnability, ease of use, understandability, quality of learning, and quality of experience [18]. Domingo and Gargante [19] conducted a study to assess the teachers' perception about using mobile technology and how learning could be influences. The study reveals that content learning applications are used more frequently compared to the informational applications. It reflects the opportunity to streamline m-learning platforms to more detailed content learning applications, which can focus on specific contexts rather than integrating various contexts in a single platform. Nonetheless, Bird and Stubbs [20] identify the challenges from adoption strategy perspective for scaling m-learning applications into institution-wide learning technologies. The study focuses on integrating m-learning into the IT Strategy of institutions and universities explained through Law/Collon model [20].

On the other hand, pedagogy is deeply rooted in m-learning. There are various pedagogical approaches in education; however, the need for identifying a sufficient pedagogical approach is rarely recognized. Lozanzo et al. [21] developed a framework for assessing the pedagogical approaches in relation to various competences in m-learning contexts. Dennen and Hao [22] developed M-Cope framework for designing effective mobile learning by considering the following five critical areas: Mobile affordances, Conditions, Outcomes, Pedagogy and Ethics. However, pedagogical approaches vary across the regions, and therefore implementation approaches need to consider and reflect cultural differences. Hao et al. [23] focus on assessing how students perceive m-learning across three culturally different regions including USA, China, and Turkey; although all students preferred m-learning approach, they raise few concerns such as support, infrastructure and embedding the cultural aspects (the local pedagogical approaches) in m-learning platforms. Kearney et al. [24] investigated the use of distinctive m-learning pedagogies by teachers and identified that online collaboration and networking were rated unpredictably lower than expected, in spite of enhanced connection and flexible learning opportunities afforded by mobile technologies. However, Lindsay [25] found that opportunities for pedagogical transformation that collaborative learning offers appear to be partially realized, but the potential for situative learning using authentic contexts.

To conclude, the majority of the reviewed literature assures the positive perceptions about adopting m-learning platforms. However, socio-cultural issues, pedagogical approaches, design and technology are the main issues identified with m-learning. Such issues are related to the users of m-learning platforms; hence, the user-centric features are one of the major aspects that are not being considered in the current m-learning platforms. Additionally, the design and technology issues concerning privacy and security, usability etc. are very common concerns that need to be addressed. Considering these concerns/factors, a user-centric design framework is proposed in the next section.

III. USER-CENTRIC FRAMEWORK FOR M-LEARNING

There are various frameworks proposed by various researchers [26]-[28] for m-learning applications. Out of which UCD (User-Centered Design) [27] and mLUX [28] are the most commonly used design frameworks. The UCD includes a series of phases including knowing the users; analyzing users' tasks and goals; developing usability requirements; prototype and design concept; usability testing; and repeating the stages for more features [26]. mLUX approach has three layers [28] which include the role players, the context of use; and the process. The role players includes all stakeholders of the m-learning application who are involved in one or more stages. The term role player defines not just the users or actors but also considers the roles of the users in relation to the application. There are also invisible role players which include individuals, organizations, systems, developers, testers etc., who are not the actual users of the application, but play important roles in

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the design and development [26]. The context of use is the capability of the application to create an effective user-centric learning environment. Several factors are to be considered in this aspect including the Social (social acceptance of application); physical (time & location constraints), and educational (learning, outcomes, pedagogical approaches). The process is a methodology for developing m-learning application which includes four stages: User Study; Data Analysis; Idea Creation; and Product Concept as shown in Figure 1.

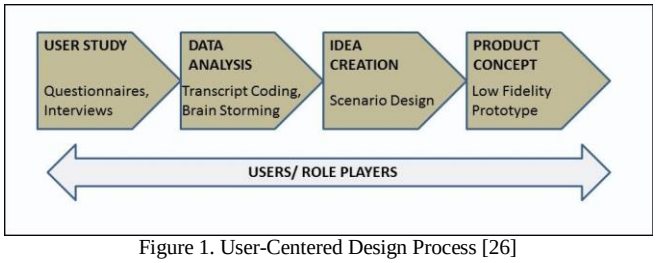

Figure 1. User-Centered Design Process [26]

The UCD framework includes some user-centric features; however, it does not cover all of the issues outlined in the above in Section II. Therefore, there is a need to develop more detailed user-centric framework and design methodology, in order to address the continuously emerging concerns. Accordingly, a user-centric layered framework is proposed as shown in Figure 2. The proposed framework aims at helping developers in adopting a streamlined approach in developing m-learning applications. It consists of the following four layers: (i) user-centered layer, (ii) socio-cultural layer, (iii) technology and design layer, and (iv) system development layer.

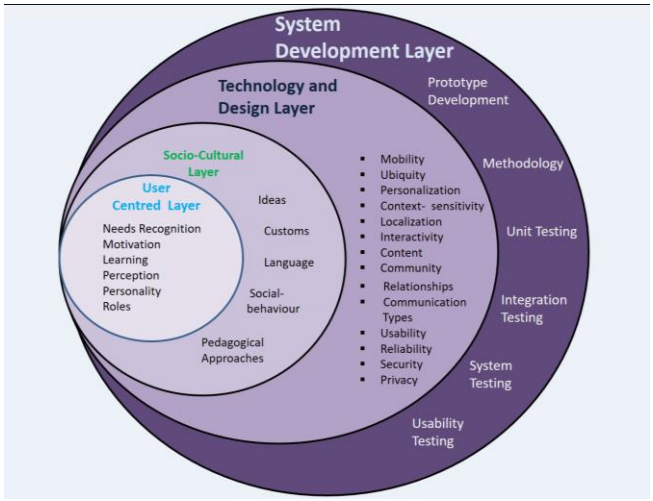

Figure 2. M-Learning User-Centric Framework

A. User-Centered Layer

This layer represents the core of the framework and reflects the user-centric aspects which need to be considered in the development of the m-learning applications. Assessing user needs and expectations is one of the first and foremost tasks in the development process. There are other behavioral aspects which include motivation (i.e., factors that enhance the user engagement); learning (i.e., factors that enhance learnability); perception (i.e., ideas and beliefs of the users about the application); personality (i.e., behavioral attitudes that define the users); and roles (i.e., various roles played by the users, such as: teachers and students).

B. Socio-Cultural Layer

Learning is a process often influenced by the cultural settings and social environment. As cultures vary across regions, so do the pedagogical approaches. Therefore, the concept of *one-size-fits-all* would be impractical in developing m-learning applications. Therefore, this layer includes the key socio-cultural aspects, which increase the adoptability and enhance the learning process using m-learning applications. These include ideas and customs which are practiced by a particular group of people or a community. Examples on such aspects include language used in the community, social behavior that defines the attitudes and behavioral aspects of a community, and pedagogical approaches followed by the community in learning process [29].

C. Technology & Design Layer

The user-centric aspects and the socio-cultural aspects must be enbeded into the design of m-learning application with the support of technology. The aspects that need to be considered in this layer include mobility (i.e., the ability of the application to be accessed on various mobile devices), ubiquity (i.e., availability of devices to receive service from anywhere on a real-time basis), personalization (i.e., ability to personalise features specific to individual users), context-sensitivity (i.e., localization and interactivity), content (i.e., the content on the application measured with completeness, accuracy and sustainability), community (i.e., users of the application), relationships (i.e., interactions between the users of the application), communication types (i.e, ways of communicating like messaging, messenger etc.), usability (i.e., ease of use, interface, enjoyability, learnability), reliability (i.e., how reliable is the application), security and privacy (e.g., data protection).

D. System Development Layer

The system development layer focuses on the factors that need to considerd for the application development. These include developing a user-centric methodology; designing a prototype and reviewing it before the actual development; adopting testing stragies like unit testing (testing individual unit/module), integration testing (testing integrated units/modules), system testing (testing the whole application), and usability testing (testing if the system meets all the user requirements).

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IV. USER-CENTRIC DESIGN METHODOLOGY

The development methodology proposed for m-learning applications engages the users in the development process along with other stakeholders including designers, developers, testers, etc. This methodology, depicted in Figure 3, is composed of two key parts: (i) the tools used to implement such steps (e.g., interview and questionnaires) and (ii) the stages/steps (e.g., identify needs) to be taken to implement the proposed methodology. Both parts are described in the next couple of paragraphs. The most commonly used tools include the following:

A. Tools/Methods Used to Support the Methodology

First: Focus Groups, which include the actual users or acting users of the m-learning application from whom the requirements, needs and expectations can be gathered for developing the application [26]. The output from the focus groups would be non-statistical and need efficient analysts to convert them in to system requirements. The process usually involves low sample population and the cost incurred is comparatively low to the other methods [30].

Second: Participatory Design, which engages the users actively in sharing the opinions and feedbacks during the designing stage [31]. This approach is mostly used for reviewing the prototype designs, which can be used later for the actual development. The output of this step would be non-statistical and requires efficient analysts to convert it in to the design specifications.

Third: Questionnaires & Interviews, used to gather the requirements from the users before developing the application and also for evaluating the system after developing the system. They can be used in both requirements gathering and evaluation stages. The output of this step would be statistical and can be analyzed using various techniques to assess the system from various perspectives. The sample size would be large and incurs fewer costs compared to other approaches [32]. In addition, interviews are one of the effective qualitative approaches for gathering the quality data which could be the requirements or feedback. The output of the interviews is non-statistical, often involves low sample size but incurs high costs [31]. Also, they can be used in both requirements gathering and evaluation stages.

Fourth: Usability Testing, which is used for testing the designs/prototypes, and also the application as a whole. The aim of the usability testing is to assess if the design/application meets the specified user requirements [33]. The output of this usability testing can be both non-statistical and statistical, often involve low sample size, and incurs high costs.

The previously described four tools or methods are proposed mainly to engage the users over the overall software development life cycle. Such engagement brings some cost, as explained earlier, but ensures effective design, development and implementation for m-learning applications.

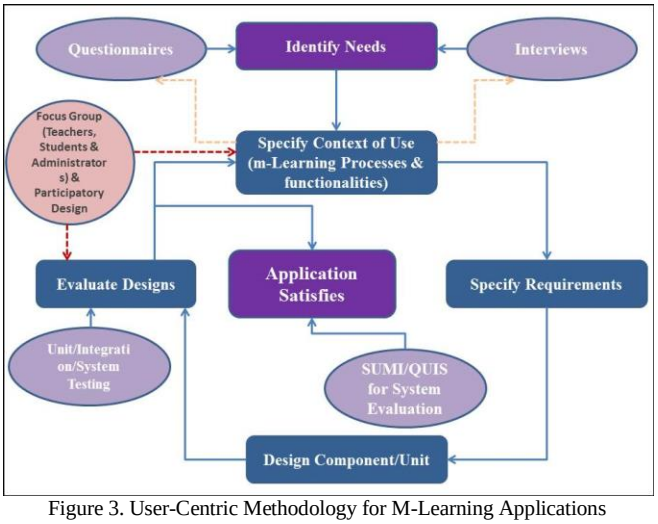

Figure 3. User-Centric Methodology for M-Learning Applications

B. Methodology Steps/Stages

The proposed methodology uses agile/iterative approach for mitigating the issues and errors during the application development. The user-centric approach specified in ISO 9241-210:2010 [34] standard is integrated with user-centric aspects in specific to M-Learning and includes the following stages of development.

Stage I – Identify Needs: Identifying the requirements of the m-learning users is the first step in the methodology, which uses interviews and questionnaires as a tool for identifying the needs, requirements and expectations of the users. Focus groups can also be involved at this stage for a more detailed assessment of needs based on their roles.

Stage II – Context of Use: At this stage the context of application is assessed by analyzing the users and their roles, location, community (i.e., socio-cultural aspects, pedagogical approaches) of using application, the purpose of developing the application, and the conditions in which the application would be used. Focus groups can be used at this stage as well to seek their ideas and opinions.

Stage III – Specify Requirements: After carefully assessing the users' needs and expectations and the context of use, the system requirements would be specified.

Stage IV – Design Component/System: The requirements outlined in the previous stage are used for designing the component/unit of the system.

Stage V – Evaluate Designs/Prototypes: At this stage, the designed components can be evaluated by using participatory approach (c-design) or by using focus groups. Unit and integration testing can be done by the testers at this stage. Repeat the process again from the context of use stage for other components till the final application is developed.

Stage VI – Application Satisfies: Once the application is fully developed, methods like SUMI/QUIS can be used for evaluating the application to ensure its completeness, correctness and consistency.

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To conclude, both parts (i.e., Tools and Steps/Stages) complement each other and lead to user-centric design for m-learning applications. The proposed framework and methodology are generic to respond to the significant variety of requirements in learning domain [35]. Implementing this framework in such a complex domain will include certain challenges. One of the key challenges could be managing the user-centric approach because more frequent requirements will continuously evolve; therefore, better requirements management approaches are required. This is expected to delineate requirements conflict and specific risks associated with that. In addition, the subtle conceptualizations of some of the factors bring further complexity to the implementation of this framework. For instance, pedagogical approaches refer to different concepts for different stakeholders. Moreover, cross-layer interaction needs to be handled. This is needed to understand for example the relationship between motivation, in the core layer, and pedagogical approaches, in the next layer. A potential recommendation to manage this concern, is to have a detailed-enough instantiation process on the top of the above-introduced user-centric design methodology.

V. CONCLUSION AND FUTURE WORK

M-Learning is one of the most emerging research areas since it simplifies the learning process with the help of mobile and communication technologies. However, learning is an aspect which is influenced by the culture and pedagogical approaches specific to a particular community or region. Literature evidences identified various user-centric concerns, such as privacy, security, adaptability, usability, learnability with respect to m-learning applications. Considering these concerns, this paper proposed a user-centric design framework and m-learning development methodology in order to address the requirements of the end users effectively and efficiently. The proposed framework addressed the concerns identified via introducing: (i) user-centric and socio-cultural aspects in the process of designing the system, and (ii) an m-learning tailored development methodology by integrating the user-centric design methods in to the agile user-centric development stages. The study can be further extended by using the proposed framework and methodology for developing m-learning applications, which remains as future work.

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