How Mature is m-Learning in an Educational Institution?

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Abstract. An m-Learning Maturity Model (MLMM) is put forward in this research study based on Critical Success Factors (CSFs) for assessing the mobile technology adoption rates in universities and higher educational institutes. The model is derived and adopted from Capability Maturity Model (CMM), which has been widely used in organizations to gauge the adoption of various new technologies and processes. Five levels of m-learning maturity are defined in the model including preliminary, established, defined, structured, and continuous improvement. Each of these maturity levels is gauged through nine CSFs in assessment questionnaire. The CSFs used in measuring instrument of the MLMM model are adopted from three of our previous empirical studies. Using an assessment questionnaire and a rating methodology, the paper replicates the model to two universities to gauge their level of m-Learning adoption. Thus, two case studies are presented to assess the applicability of the model. Although the model has certain limitations in terms of omitting factors such as cultural influences on m-Learning adoption, the included CSFs have been validated by earlier empirical research. Hence the model provides a comprehensive approach, while opening new areas of future research.

Keywords: Electronic Learning, Mobile Learning, Learning Systems, Computers in Education, Capability Maturity Model.

1 Introduction

Mobile technology has become a ubiquitous part of our daily lives by offering innovative ways to communicate, gather and share information, and entertain. At the same time, by diminishing the boundaries and limitations of space and time, mobile devices have the potential to enrich the learning experience of learners. Acknowledging this applicability and potential, many educational institutes have started adopting them as a tool to extend and facilitate learning to students. However, unlike various existing maturity models [1], [2], [3], [4], no specific m-learning maturity model is available to date to test the adoption rates in universities and higher education institutes. Consequently, this paper presents a maturity model preliminary framework that is based on current understanding of the issue.

Adopting the Capability Maturity Model (CMM) as the underlying framework and making appropriate modifications, this research work proposes an M-Learning Maturity Model (MLMM) with the aim to gauge the maturity of m-learning adoption amongst higher educational institutes. Furthermore, the model takes into account various critical success factors to enable the assessment of m-Learning adoption from different perspectives including University Management, students, and instructors. Additionally, the paper also offers a rating methodology and assessment questionnaires. To test the proposed model, case

2 Literature Review

This section presents theoretical background for the critical success factors for m-Learning

2.1 e-Learning Maturity Model

A maturity model is used as a diagnostic tool to assess the maturity of a process to identify areas of improvement. In the field of software processing, CMM is the most appropriate model since its utility is not just limited to the software process domain, but extends to the entire organization. The CMM framework is composed of five levels: Initial, Repeatable, Defined, Managed, and Optimization. Every level is composed of the key areas of process on which the activities of the organization are focused [5].

The CMM can be used in different areas of application, such as in evaluating the E-Learning platform within the educational or a university set up [6]. Marshell and Mitchell modified the CMM, focusing on improving and boosting the adoption of the process, to come up with the E-Learning Maturity Model (EMM) [7].

Nevertheless, although both of the models were clearly for different application areas, the goals of EMM were similar to the goals of CMM. However, no specific model exists for adoption of m-Learning in educational institutions. The use of EMM for the m-Learning platform is not suitable because the permanent mobility of the technology platform has added many parameters to m-Learning that are not required for E-Learning [8]. Rapid technological change is one of the many barriers to m-Learning. Therefore, E-Learning and m-Learning do not follow the same curve [8]. Furthermore, the implementation of m-Learning platform varies across different institutions because of differences in factors that may lead to faster or more efficient adoption of m-Learning tools. The procedure provided Hain and Back [9] can be taken as a road map to develop a framework for assessment of m-Learning within an institution.

2.2 Framework for m-Learning Maturity Model

This proposed model is based on our previous studies from three perspectives including university management, instructors, and students [10], [11], [12]. The factors which are based on identified m-Learning CSF represent the dependent and the independent variables in m-Learning success, and they provide the underlying assumption of this theoretical model, i.e., the actual m-Learning adoption.

Having an overall assessment framework is important to determine the tangible requirements and the specific attitudes for adopting m-Learning. The main objective of this paper is to develop a maturity model that will be flexible and robust while providing users with a guiding framework for enhancing the process of m-learning. Our literature review showed that such a model on the line of the existing CMM could be beneficial to all the stakeholders.

This paper focuses on developing an m-Learning maturity model (MLMM) by adopting the CMM as the underlying framework to assess the maturity of an educational institute in adopting m-Learning. Table 1 shows the set of nine different success factors. The degrees to which management and faculty members are in agreement with each statement in the questionnaire determine the m-Learning maturity of the university. Each factor will be identified by the use of following set of abbreviations: Learning Made Interesting (LMI), Increased Productivity (IP), Blended Learning (BL), University Learning practices (ULP), Internet access (IA), Instructor autonomy (IAU), University's commitment to m-Learning (UC), Change management practices (CMP), and Technical competence of instructors (TCI).

Table 1. Framework of m-learning maturity model.

CSFs of m-Learning	**Result based on previous study**
Learning made interesting	Study [10]
Increased productivity	
Blended Learning	
University learning practices	Study [11]
Internet access	
Instructor autonomy	
University commitment to m-Learning	Study [12]
Change management practices	
Technical competence of instructors	

3 Mobile Learning Maturity Model (MLMM)

The five levels of the MLMM are listed below. For each level, different statements based on CSFs must be satisfied to achieve maturity at that level.

3.1 First Level: Preliminary

At this level, universities and the institutions do not consider mobile devices to be important in the provision of their services and products. It is a reactive and experimental stage that recognizes the need to improve provision of information through mobile devices. The institute lacks vision and measures for implementation of the prototype. A number of limitations exist, like the limited coverage of mobile devices and limited understanding of m-Learning's value by students.

3.2 Second Level: Established

Subsequent paragraphs, however, are indented. This level is based on the recognition of the opportunity provided by mobile devices in the education system and, particularly, in blended learning. This stage is characterized by interest from students and instructors resulting in investment in m-Learning technologies by the institute. Thus, while institutes guide and facilitate m-Learning implementation, they lack the ability to evaluate the m-Learning systems. This brings the need for improvements in the existing and implemented pilot prototypes using the nine CSFs to achieve m-Learning maturity to this level.

3.3 Third Level: Defined

In the defined level, mobile device is considered critical for the interaction among students, instructors, and administrative staff. In order to succeed at this level, the learning institutions must link their m-Learning strategies with core and technical visions; invest heavily in the system; and have a well-defined change management plan to carry out the m-Learning transition.

3.4 Fourth Level: Structured

In the structured level, m-Learning is characterized by optimization and innovation. The optimization results in a rich, dynamic, and flawless experience for students and instructors in using m-Learning system. The University uses techniques to refine procedures and policies to control any changes experienced in m-Learning that help and increase students and instructors engagement. The use of mobile device applications allows students to provide feedback, give comments, and share information. As a result, institutions refine and improve procedures and policies to control any changes experienced in mobile technology.

3.5 Fifth Level: Continuous Improvement

Finally, the highest m-Learning maturity level is the continuous improvement level. In this stage, m-Learning has already been accepted as the best approach to provide knowledge and exchange of information between students and instructors. In this stage, institutions are constantly evaluating themselves to ensure continuous improvement and optimization. This helps to identify any changes that might limit or change the manner in which m-Learning is used.

4 Performance Scale and Rating Methodology

A five-level scale is used to rate the performance of the university and establish the maturity level. The extent to which the m-Learning achieves the specific maturity level while meeting the requirements, and the extent to which the university agrees with the statements in the questionnaires show the quantitative rating. The ratings used to determine each m-Learning factor– such as “Completely Achieved,” “Largely Achieved,” "Partially Achieved," "Unachieved," and "Inapplicable" – are shown in Table 2. The rating of "Inapplicable" has also been included in the model to enhance the suppleness of our process. In order to maintain the consistency of our assessment of m-Learning with already validated and accepted popular scales, we have structured performance scales and their limits close to the BOOTSTRAP methodology [13]. However, according to the design of the questionnaires in our model, MLMM, the linguistic expressions have been slightly changed. Therefore, we have used the self-assessment approach in our methodology.

Table 2. Performance scale.

Scale No.	**Linguistic Expression of Performance**		**Rating Threshold (%)**
	MLMM	***BOOTSTRAP***	
4	Completely Achieved	Completely Satisfied	≥ 80
3	Largely Achieved	Largely Satisfied	66.7 – 79.9
2	Partially Achieved	Partially Satisfied	33.3 – 66.6
1	Unachieved	Absent / Poor	≤ 33.2
0	Inapplicable	Does not apply	–

We have used terms such as m-Learning factors Rating (mLRt), Number of Achieved Statements (NAS), Passing Threshold (PT), and m-Learning Maturity Level (MLML). In the statistical equation for our maturity model, the following abbreviations and symbols are used:

MF = m-Learning Factor
MFN = M-Learning Factor Number (an integer)
ML = Maturity Level (an integer)
S = Statement
SN = Statement Number (an integer)
NAS = Number of Achieved Statement

Let MF_t [i, j] be a rating of the ith CSFs of the jth maturity level. Subsequently, according to the scales defined in Table 3, it can be summarized as:

mLR_t [i,j] = 4, if the Achievement of the condition / statement is at least 80%
= 3, if the Achievement of the condition / statement is from 66.7 to 79.9%
= 2, if the Achievement of the condition / statement is from 33.3 to 66.6%
= 1, if the Achievement of the condition / statement is less than 33.3%
= 0, if the condition - statement is not applicable.

An ith condition/statement at the jth maturity level is considered Achieved if mLRt [i, j] ≥ 3 or mLRt [i, j] is 0. The number of conditions/statements Achieved at jth maturity level is defined as:

$$NAS\ [j] = Number\ of\ \{mLR_t[i,j] \geq |Achieved\} = Number\ of\ \{mLR_t[i,j]\ |mLR_t[i,j] \geq 3\ or\ mLR_t[i,j] = 0\}$$

The m-Learning maturity is considered to be achieved if 80% of the conditions or statements in the questionnaire are achieved. Thus, if TNS [j] is the Total Number of Statements at the jth maturity level, then the passing threshold (PT) at the jth maturity level is defined as:

$$PT\ [j] = TNS[j]\ * 80\ \%$$

Table 3. Rating Threshold for the m-learning maturity assessment.

m-Learning Maturity Level	**Total Questions**	**Pass Threshold (PT) 80%**
Preliminary	0	Not Valid
Establishment	18	14
Defined	20	16
Structured	20	16
Continuous improvement	17	14

The MLML is defined as the highest maturity level at which the number of achieved conditions or statements is greater than or equal to the passing threshold (PT) [j]; hence:

$$MLML = \max\{\ j\ |\ TNS[j]\ \geq PT[j]\}$$

4.1 Reliability and Validity Analysis of Questionnaires

Reliability and validity are two necessary characteristics of any experimental study. The construct validity and the reliability of the questionnaire designed were analyzed with the help of a pilot study. We selected five universities which are implementing m-Learning platform, so as to carry out a study guide. Firstly, we established contacts with the Deans of department in these universities. Emails were sent personally to describe the objectives and scope of the study. As a result, responses were received from 20 participants (dean and faculty members) from three universities. They gave us their consent to each condition in the questionnaire.

Reliability is referred to as consistency. First of all, the reliability of the multiple-item measurement scales for the four maturity levels (levels 2, 3, 4, and 5) were estimated by means of an internal consistency analysis, which was executed with the coefficient alpha [14]. Our evaluation showed that the coefficient alpha varied from 0.91 to 0.96. Nunnally and Bernste [15] maintain that a reliability coefficient higher than 0.70

for a measuring instrument is acceptable. Our analysis shows that the questionnaire developed for our maturity model were approved by the criteria of Nunnally and Bernste [15], so we have concluded that all the items built for this experiment are reliable.

Validity, which refers to the degree to which a measurement replicates the accurate value, was performed in the second step. According to Campbell and Fiske, when scale items associate and budge in a similar direction for a provided assembly then the convergent validity will occur. Principal component analysis (PCA) [16] was performed for all nine of the m-Learning CSFs in each maturity level. Precisely as a reference point, we utilized the Eigen value [17] to observe the construct validity using principal component analysis (PCA). In this study Eigen value-one which is also called the Kaiser Criterion [18], [19] criterion has been used. All the components maintain an Eigen value larger than one. Eigen value analysis shows that a single factor can change items in questionnaires completely. Hence, we get to the conclusion that the convergent validity can be observed as sufficient.

5 Case Studies

According to Flyvbjerg [20], "The case study is useful for both generating and testing of hypotheses but is not limited to these research activities alone." Thus case study can be helpful in the beginning steps of a study by providing hypotheses which can be experimented scientifically.

Our model was applied to two m-Learning programs in two universities (*country name removed*) to perform the m-Learning maturity assessment. The universities will be referred to as "University A" and "University B," to protect their privacy. Using a Likert scale ranging from 0 to 4, the participants were requested to provide the degree of agreement with each statement for the questionnaires designed [(0 Inapplicable), (1 Unachieved), (2 Partially Achieved), (3 Largely Achieved) and (4 Completely Achieved)]. Consequently, the questionnaire was completed by the participants starting from Level 2 and finishing at Level 5.

The respondents of this study included the Dean, higher management staff, or a faculty member. Survey link (SoGoSurvey tools) and email were the means of all communication with the respondents. The participants in the study had consented to their involvement and they were not paid any reimbursement. In the following sections, both case studies are discussed. Bias in the sample is limited because multiple responses were received from each university. A more accurate description of the m-Learning was provided by different respondents. Inter-rater agreement analysis has also been performed and the degree of agreement among all the raters within each university is known and provided information. The following section describes the analysis.

5.1 University "A"

University "A" has a Blackboard system and we received a total of 8 complete responses from the university. As proposed by the rating method conferred in Section above (IV-B), if the performance scale is larger than or equal to 3 or 0, then statements are considered to be agreed upon. We have calculated NAS (the Number of Achieved Statements) for all the levels. NAS is 14 for Level 2, 15 for Level 3, 1 for Level 4, and 1 for Level 5 from the data collected. NAS at Level 2 has a pass limit of 80% according to the rating limit for our MLMM. University (A) is therefore at the “Established” maturity level. As the value of the statement is 3, it is considered that level 2 is largely achieved.

5.2 University “B”

University “B” has its own Learning Management System and we received a total number of 8 complete responses from the university. According to the rating method discussed in Section IV above, if the performance scale is larger than or equal to 3 or 0, then a statement is considered to be agreed upon. We have calculated NAS (the Number of achieved statements) for all the levels. NAS is 17 for Level 2, 2 for Level 3, 0 for Level 4, and 0 for Level 5 from the data collected. NAS at Level 2 has a pass limit of 80% according to the rating limit for our MLMM. University (B) is therefore at the “Established” maturity level.

Summarized assessment results for both case studies are given in Table 4.

Table 4. Summary of assessment results of case studies.

MLML	Total Questions	Pass Threshold (PT) 80%	University “A” NAS	University “B” NAS
Preliminary	0	Not Valid	-	-
Established	18	14	14	17
Defined	20	16	15	2
Structured	20	16	1	0
Continuous Improvement	17	14	1	0

5.3 Analysis of Inter-Rater Agreement

The extent of agreement between different raters within one university is provided by inter-rater agreement [21]. According to Lee et al. [22], the assessment of the identical methodologies adheres to inter-rater agreement and conforms to reproducibility. In cases where data is ordinal, the Cohen’s Kappa [23] is preferred to evaluate inter-rater agreement.

An inter-rater agreement analysis has been conducted in our study using Kappa statistics. 17 respondents participated – 8 from university A and 9 from university B. The values of Cohen’s Kappa and the Fleiss Kappa coefficients can range from 0 to 1, with 0 indicating perfect disagreement and 1 indicating perfect agreement [24]. In University A, the benchmark for Kappa does include four level scales, where < 0.44 is poor agreement, 0.44– 0.62 is moderate agreement, 0.62–0.78 is substantial agreement, and > 0.78 is excellent agreement. For University A, the Kappa coefficients range from 0.45 to

0.85, as summarized in Table 5 below, and therefore, are classified as moderate agreement.

Table 5. The inter-rated agreement analysis of university "A".

MLMM	**Fleiss' Kappa Statistics**		**Cohen's Kappa Statistics**	
	Coef.	***Z***	***Coef.***	***Z***
Established	0.85	36.14	0.85	36.56
Defined	0.73	32.79	0.73	34.15
Structured	0.45	26.40	0.47	36.21
Continuous improvement	0.69	35.71	0.69	36.60

Likewise, the Kappa coefficients ranged from 0.43 to 0.79 when we did same analysis for university B; these are shown in Table 6. Thus, in the case of university B, coefficients are classified as being moderate agreement too.

Table 6. The inter-rated agreement analysis of university "B".

MLMM	**Fleiss' Kappa Statistics**		**Cohen's Kappa Statistics**	
	Coef.	***Z***	***Coef.***	***Z***
Established	0.63	26.99	0.64	29.10
Defined	0.60	38.07	0.61	42.68
Structured	0.79	38.27	0.79	38.56
Continuous improvement	0.43	17.86	0.45	22.26

6 Discussions

In software engineering, maturity model information about different processes is provided including their current maturity levels and their related activities. An organization can seek help from this information to upgrade their processes, plan their future activities, and design strategic plans. End user experiences can provide great help to improve the software projects. Consequently, m-Learning and correlated problems are the key areas of study in academic society. Assessment is needed to determine particular areas where improvements are compulsory.

M-Learning is a relatively new disciplinary research area, and m-Learning adoption requires a comprehensive strategy due to its continuous adoption. In previous work that we have done, we examined different key factors of m-Learning adoption .The significant key factors are the measuring instrument to introduce an MLMM in the assessment methodology for m-Learning. The structural MLMM composition consists of the evaluation framework from three dimensions relying on university management approach, and on students and instructors.

Consequently, the current maturity of an m-Learning platform is assessed by this model with assessment methodology of defining and conducting case studies. An integral feature of the MLMM is the methodology for specifically evaluating m-Learning platform maturity. This model will help university management perform adoption assessments for their m-Learning projects and boost their upgrading strategies.

7 Limitations of the Assessment Methodology

Our MLMM is questionnaire-based and, hence, it is vulnerable to certain limitations. Even though our model, which is based on three empirical studies, combines five maturity levels and nine CSFs, we may have inadvertently omitted other factors that affect m-Learning maturity, such as culture.

We applied the most commonly used approaches in our reliability and validity analysis, and in our measurements. Since m-Learning is not considered a top priority in the educational institution even today, we obtained a limited amount of data from universities to implement m-Learning.

Although we recognize the limitations of our model, we believe that the m-Learning CSFs have been validated through empirical investigations and thus provide a comprehensive approach and a firm foundation for future research in this area.

Software vendors or the software developer perspective, such as vendors of an m-Learning management system, which are named as the industrial perspective of the m-Learning platform, have not yet been studied. This will require future investigations.

8 Conclusions

Our MLMM is based on nine key factors, and we have empirically analyzed and identified them in the three previous studies. The area that is less attractive to the researchers is the CSF assessment of m-Learning, and, accordingly, a process that estimates the m-Learning maturity is the main contribution of this work. An evaluation questionnaire for four of the five maturity levels is part of composition of the framework of this model, as well as a rating methodology and a performance scale. Additionally, we have also studied the execution of two m-Learning projects in two universities and discussed the findings as case studies. Leaving the limitations aside, this work has contributed to setting up an all-inclusive approach for m-Learning maturity and addressed the imperative subject of factors of evaluation in m-Learning.

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