

Essential Aspects of Learning Content Development in Context Aware and Adaptive Mobile Learning Applications

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Summary

The learning content for mobile learning applications is one of several prime factors to play vital role in the resultant success of the applications or systems for mobile learners. The stress is on developing m-learning content that fits well into the mobile learning applications operating among several various contexts and adapting to these contexts. This paper showcases the aspects of mobile learning application that have impact on the mobile learning content development process, and introduces a generic process for m-learning content development, followed by a process to support continuous modeling of m-learning content for ever changing needs of any given context aware and adaptive mobile learning applications.

1. Introduction

The use of computers and related technologies for learning has been observed in various forms which we term it as e-learning. Recently, with the surge in the usage and advancement of mobile devices and related technology is making the researchers more interested in looking for the methods and techniques to carryout the learning process through these mobile devices and mobile technology, which is termed as m-learning or mobile learning.

M-learning has been projected as the future of learning or it could become an unseparable part of educational system in the future. Many definitions are given for m-learning; Leung [23] identifies four characteristics for m-learning : dynamic by providing up-to-date material and resources, operating in real time by removing all constraints on time and place, adaptive by personalizing the learning activities according to the learner background and collaborative by supporting peer-to-peer learning.

The various views of researchers on mobile technologies and its content is worth to consider. Mobile content is any type of media structured for mobile devices, like graphics, tones, films and games [35]; that is delivered through mobile internet [21], using interactivity [18]. In relation to the context of mobile learning, it can be said as "... any service or facility that supplies a learner with

general electronic information and educational content that aids in acquisition of knowledge regardless of location and time..." [22].

Few of the m-learning projects have addressed the problems of adaptation of learning tasks and personalization of course content based on student's model, learning styles and strategy [4, 12]. Characteristics [7] of mobile learning include: a) Urgency of learning need, b) Initiative of knowledge acquisition, c) Mobility of learning setting, d) Interactivity of the learning process, e) Situatedness of instructional activities and f) Integration of instructional content.

The research by Norbayah et. al. [25] measures the potential of mobile content in learning to increase learners' tacit knowledge development. At Ultralab m-learning project, the team produced m-learning materials for people with literacy and numeracy problems [9]. One of the most straight forward application for the usage of mobile devices as educational supporting tool is messaging where in the learning content is delivered to the learners is implemented in many research experiments [32, 33, 30, 13, 10]. Y.S. Chen et. al. [6] used content-based butterfly image learning (BWL) system.

This paper showcases several aspects of m-learning content development in section 2 and in section 3 a generic process is presented for modeling m-learning content. Section 4 briefs about the method that supports the much needed continued modeling of m-learning content due to ever changing needs of mobile learning applications' needs. Finally section 5 concludes the paper.

2. Aspects of m-learning content development

Unlike regular learning content developed for any e-learning application or else to that matter to any specific requirement, the learning content for mobile learning systems is influenced by many a

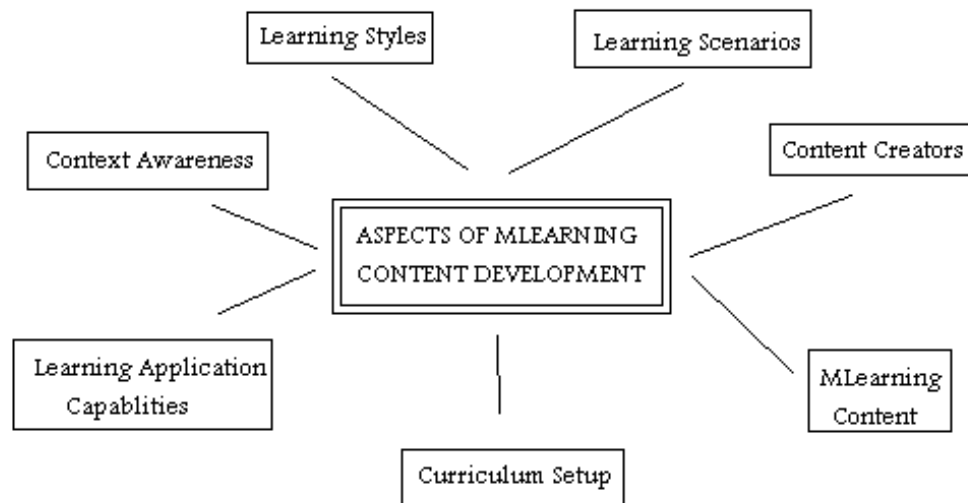


FIGURE 1: Aspects of m-learning content development

good number of elements having impact on the content creation and delivery. The very nature of the mobile learning brings these elements into its fold for successful implementation and execution. This motivates the m-learning content creators to consider these aspects in the content development process for modeling the learning content that best suits to a given situation or application. Figure 1 shows these aspects at a glance.

The most influential aspect of m-learning application is said to be the learning styles' consideration for an effective impact of the learning content over the learner in any learning activity. The learning styles designates everything that is characteristic to an individual when he/she is learning, i.e., a specific manner of approaching a learning task, the learning strategies activated in order to fulfill the task [11]. Coffield [8] has identified 71 models of learning styles, among which 13 were categorized as major models according to their theoretical importance, their widespread use and their influence on other learning style models. Whether stable or flexible, genetically determined or experience related, psychological traits or strategies, all categories of learning styles have been proven to exert an influence on learning [11]. In the model [16] by I-Hsueh Tsai et.al., for the development of mobile learning curriculum model, proposed 6-stages; among these, the emphasis was on the design and development of mobile learning content as an integral part for completeness. Personalization of the teaching material has been studied and evaluated in the area of psychology of learning and teaching methods [34, 24, 3].

The awareness of learning context is important. A learning system that examines the learning context shall

adapt learning process with respect to context change [38]. This learning process is enriched by the learning content it presents to the learner making his/her more involved in the learning activities through his mobile device. Anna Trifonova highlights the need for the dependency of the content could be relative to location context (i.e., the system knows the location where the learner resides and adjusts to it), temporal context (i.e., the system is aware of time dependent data), behavioral context (i.e., the system monitors the activities performed by the learner and responds to them adjusting its behavior) and interest specific context (i.e., the system modifies its behavior according to the learner's preferences); and a mix of these is possible and likely. Sharifi et.al.,[31] argued that mobile applications must have context-awareness and personalization as integral parts of the application, and adaptive user interfaces must be generated for the learner, firstly, to maximize learning potential at different locations, and secondly, to decrease the limitations of mobile devices such as the usability of the small screens [1,29].

In the Electronic Guidebook [15], mobile web content was specifically created for the Exploratorium museum (an interactive science museum) in San Francisco. It was noted that the purpose of context-awareness is to facilitate learning on mobile devices [1]. In the project [20] at Tampere University of Technology, the study-content is presented in the form of a game and the electronic device is used to measure the average students' knowledge level and to adopt the speed of presenting new material to the learners.

The Kidsroom project [2] at MIT Media laboratory provided a room that guides children through an interactive storytelling game. Navigation of learning

materials is adapted according to the activity context. In the study [26] at CMU a mobile device is used along with a robot, to educate visitors in museum. Spatial context and spatial interface are used to present different multimedia learning information at different demonstration places.

In carrying out learning activities of many a number of domain dependent learning process, the activities need to be performed in a specific order or fashion that is structured by the tutor/facilitator so as to accomplish a major task is termed as a learning scenario. These learning scenarios are populated by the tutor to the most and highly coupled to the learning content delivered or operated on, during the learning process for successful execution and to obtain better results as such.

The learning application capabilities are more concerned with the different forms of interactions the learning tool provides, different options that are given to the mobile learner for a given learning activity, the forms of support provided to learner when he carries out the learning activity, the data logging capabilities of the learning tool and more importantly the forms of presentation capabilities of the learning tool; all of these will help the content creators to give various modeled alternatives of learning content for various requirements compatible to the application capabilities.

As the course structure is the base for any educational structure, and is must for consideration when the learning process is supported by any mobile learning application. The course structure includes several major activities to be carried out by the learners, like: class-work, class-handouts, assignments, quizzes, experiments of lab work, projects to carryout, assessments to take and so on, depending on the institutional policies. Each of these activities demand the modeled learning content to be appropriate for them to achieve their intended objectives when the learners carryout them. For e.g., the content for quizzes may take a form that is entirely different when taken for that of assessment and which will be different from the one for class-handouts (in this case electronic copies to the learners' mobile devices) and this chain of differences continues to the remaining ones. Such modeling of learning content for all these varying requirements is possible by identifying the meta information, various attributes and functionality of each, and formulating techniques and strategies to incorporate to match the compatible and capable dimensional values for the attributes of the learning content model.

3. Modeling Process for M-learning Content

The learning content development is very crucial phase and cannot be interpreted as minor task of the entire m-learning application development process. The basic materials that form the low level content has to be transformed into higher forms of content by following a process that treats this low level materials against various aspects like syllabus, structure & scope, learning scenarios, learning styles, various contexts among which the learning content is delivered and adapted to. This needs to be carried out in a well defined fashion. We present here the five stage process model for learning content modeling and development where in all the above said aspects are considered in each of these phases. In the generic process for content modeling presented in the figure 2, each stage will result in intermediate learning content models/designs that are specific to that stage-level and can be utilized in an m-learning application considering only those aspects of that stage for its execution. For example, if a preliminary form of m-learning application is to only deliver learning content to the learners' mobiles according to their course specifications, then such an m-learning application can pause before entering to stage two and use the intermediate learning content model/design produced by the stage one of this process. Similarly, each stage of this process will enhance the design of the learning content by considering the various aspects of m-learning needs in stage wise manner, thereby giving applications a scope for future scalability options from learning content dimension.

The basic form of learning content is a set of raw materials such as lecture slides, images, clips, animations, selected-passages, FAQs and so on. These are the materials created by various tutors and instructors using several authoring tools of their convenience and importance. These materials are very basic to use for any particular application or situation or scenario so as to produce good results. These materials need to be given more appropriate form that enables the tutors to combine or relate or mix for various levels of instruction to the students.

This will help the tutors or instructors to look at first what has to be selected and represented in the various forms. The first and foremost criterion is to get these materials that fit into the course structure that is being adopted for a learner or group of learners. At this first stage, the course structure provides details like what are the different course-level-activities a student/learner has to undertake.

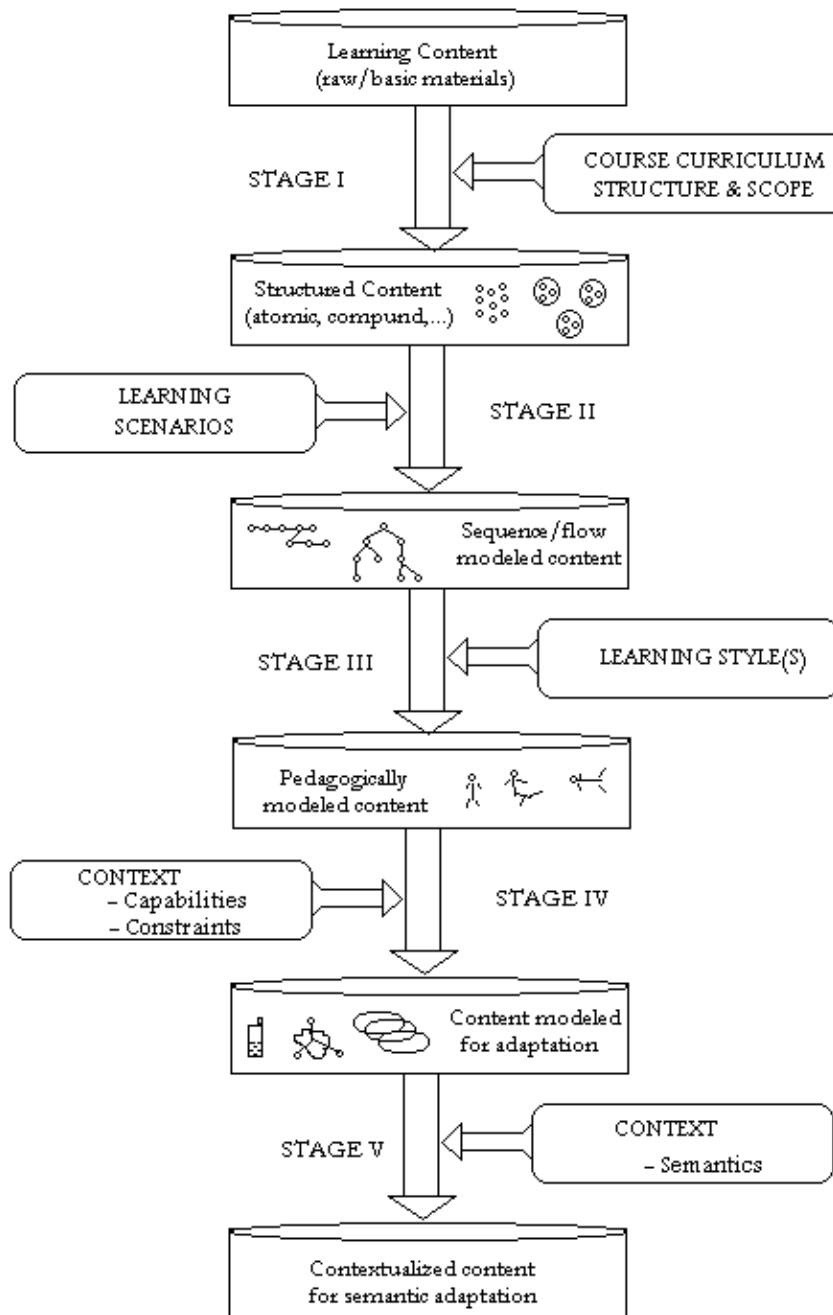


FIGURE 2: A Generic Process for Modeling M-learning content

For example, these include: The classes he/she has to attend/take, the assignments and their format to submit, the experiments he/she has to conduct/participate in, the projects he has to carry out, the assessments/exams he/she has to take. All these course-level activities has their own demands and formats to follow, which a designer has to

transform into mobile technology supported activities; in such a design process he/she has to identify the attributes of the learning content that need to be given the values which will map to the activities and also the mobile supported tasks,

i.e., the instructional strategies of the course structure are transformed into mobile technology supported instructions. At this stage I, the design process will end by identifying the different forms of learning content that exists in different levels of structural existence like atomic-level, compound-level, unit-level, flow-level and so on. It is recommended to have a set of rules/constraints to aggregate the atomic level learning content into a compound level and then to next levels like flow-model level based on certain specific framework and set of well defined mechanisms.

Many learning activity models or systems have been devised to support indoor, outdoor or interactive class room learning, still the learning content significantly influences the learning results. The study [37] insists on defining learning content as a learning activity plus appropriate material for use in that activity; namely, content = activity + material [5]. The learning content quality involves designing elaborated and detailed learning activity to support different learning scenarios. Over and above, the design aspects of the learning content must imbibe in it the various possible learning scenarios that are of different in their nature and objectives. Any m-learning activity can be placed into a certain category of learning scenario where the learners use their mobile devices to carryout a set of learning activities resulting in a major task completion. This directs the designers to identify set of learning scenarios that may become part of the m-learning application that is in development. Each of the identified or possible learning scenarios, are actually delivering the learning content in a certain specific sequence that serves the purpose of achieving the objective of that learning scenario. The stage II of this process helps the designers to identify the attributes and dimensions of the m-learning content coming under various learning scenarios in various sequences and flows.

The Stage III of the process helps the content creators to incorporate any or some of the learning styles [27, 17, 14, 19] that exists in the literature. Every learning style categorizes the learners into different categories (figure 3) and the learners of each category are then named with a learner style. Each learner style has its own type of selected learning material. Each learner style has their own recommended representation of learning content and also has their own representation type that results in effective learning process resulting in finer results.

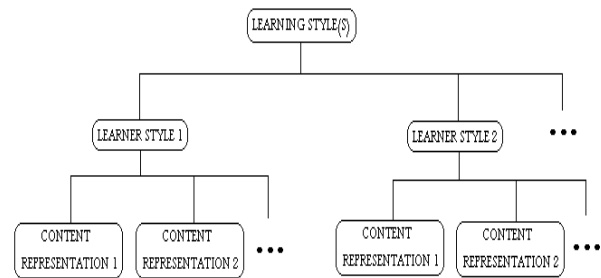


FIGURE 3: Learning Styles & Content Format

For example, Honey & Mumford learning styles questionnaire [28] categorizes the learners into categories like Theorist, Activist, Reflector and Pragmatist. And for a learner style like reflector the selected learning material must be example-oriented learning material, and for pragmatist it is exercise-oriented learning material. If Dunn & Dunn model is considered, then we can go for learner styles like auditory, visual, impulsive and some more; where in the auditory learner style's recommended representation of learning content is PowerPoint-style with synchronous audio, no text and for visual it is diagrams, illustration, graphs, flowcharts. Similarly the learning style dependent factors can be incorporated into learning content design in the stage III of the process model.

The need for adapting the learning content in an m-learning application that considers various physical & device contexts is imminent. The physical & device contexts considered for adaptation can be network capacities, bandwidth, type of communication, device processing-power, device battery power, device screen area, device storage capacities and many more contexts, combinations of them are possible. In such an m-learning application where in these various contexts come into play is bound to have their impact on the learning content delivered as part of the learning process. The dimensions, attributes and the possible values of these contexts are well understood and corresponding affecting values of learning content are modeled for adapting the learning content to these contexts. The resultant of this stage is the learning content modeled for adaptation to various contexts (figure 4) as part of the m-learning application adaptation strategies.

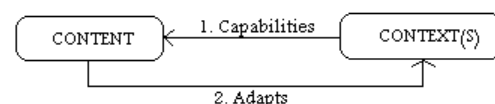


FIGURE 4: Content Adaptation

The next stage, V and final one of the process accommodates designers to identify the various contexts considered in the m-learning application at their semantic

levels. The stage five, here, models the learning content based on the many semantic contextual factors that an m-learning application takes into account. This type of modeling of learning content helps in the design of m-learning applications for Interactive-museums, Game-based learning and those in which the learner's environmental elements have high involvement in the extraction of the learning content exactly matching to the situation in which the learner is in (figure 5) and presenting them as part of the learning activity to achieve their intended objective of enhancing the knowledge of the learner about his current environment or about the elements of the environment.

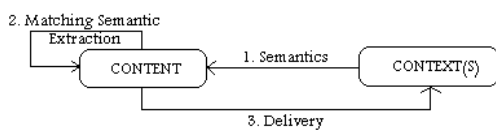


FIGURE 5: Content Contextualization

This process was incorporated in the case study [36] as part of phase 1; where in learning content was modeled to best suit the need of the mobile learning application; in which the undergraduate students' learning experience and interests were explored when mobile technology is used for their learning activities.

4. Continued Modeling of M-learning Content

One of the factors of success for any mobile learning application is the model of the learning content and its acceptability by the learners of the system. The continued support offered by the m-learning application to learner to carryout his/her learning activities thus needs

the continuous modeling of the learning content that is delivered to him/her as part of it. This continued modeling needs a few more steps to be considered in addition to the modeling process discussed earlier. Once the m-learning content is modeled, it is put into use by the base m-learning application; which at the time of production support comes up with many issues that need to be addressed in order to satisfy learner to get more interested in the m-learning system to carryout his/her learning activities. The issues that come up may be the ones that need to be considered from two directions: one type of issues may be related to the pedagogical aspects or learning scenarios or semantic perfection and the other type of issues may be related to those that deal with structural and technical aspects such as physical & device context adaptation, delivery mechanisms, context model to use, adaptation techniques, presentation styles, and related technical issues. These two types of issues are handled by two separate groups of personnel namely the tutors/instructors/facilitators and the second is the technologists/SMEs.

These issues are focused, analyzed by collecting the usage aspects from the data-logs, usage- logs populated by the devices of the system as part of the learners learning activities. In addition to these automatically collected data, it is also possible to conduct interviews for the learners to collect their views, expectations and suggestions towards the m-learning application they are using for their learning process. To get any specific additional details, questionnaire can also become an alternative to gather some more data for supporting continued modeling of the m-learning content.

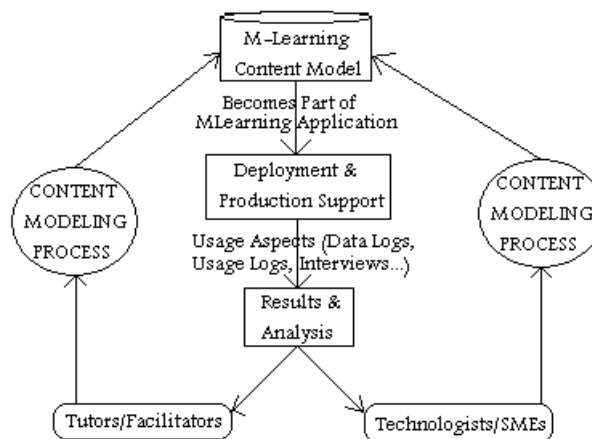


FIGURE 6: Continued Modeling Process

These two different types of issues will form the two different cycles of the modeling process for enhanced quality in the learning m-learning content model. At any stage of the processes discussed so far, the activities can be manual or semi-automatic or complete automated in their form depending upon the resources available.

5. Conclusion

In this paper, we have showcased the various essential aspects of mobile learning content development – learning styles, learning scenarios, content creators, curriculum setup, m-learning content, context awareness and m-learning application capabilities for better understanding and incorporating them in a process presented here for modeling content as per these aspects required for any mobile learning application / system for achieving better results. The continued modeling process briefed helps to model learning content for those m-learning applications that are scalable with time and need, in particular.

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