Designing A Practical Learner Model For Adaptive And Context-Aware Mobile Learning Systems

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Summary:
The concept adaptive mobile learning has become increasingly popular in the educational sector, opening the door for a new generation of systems that have changed the traditional paradigms of teaching and learning. It provides students with a myriad of advantages that make them able to access information at anytime and anywhere in a personalized way that would have been impossible few years ago. Even if many researches have attempted to meet learners' needs and characteristics to develop adaptive m-learning applications, few works have paid considerable attention to combine learners' characteristics, current environment and situation in way to effectively determine their context in real-time execution. For this purpose, a new model of adaptive m-learning systems was suggested in this paper based on a deep analysis and critic of the existing works. The proposed solution takes into account learning styles, knowledge, behavior, learning progress, satisfaction, preferences as well as environmental parameters including location, noise and motions. These characteristics are considered the most important ones to achieve the target of this adaptation which is to deliver appropriate contents and formats of presentation.

Key words:
Mobile Learning; Adaptive Learning; Context; Personalization; Learner model; Learner characteristics

1. Introduction

The progress of internet and web technologies has a great impact on our daily lives, making people's both personal and professional activities possible anywhere and at anytime [1][2]. Nowadays, mobile devices as a good example of this progress has become widespread, more effective, portable, reasonably priced and easy to use [3]. This progress is obviously required because of people mobility which has become a significant issue in many facets of our modern societies. Consequently, ubiquitous technologies in general and mobile devices in particular have affected various sectors including education, transport, banking, tourism and health [4][5]. In this context, the combination of the educational sector with mobile technologies allows us to talk about the term mobile learning (m-learning) as a natural evolution of e-learning which is a crucial concept in the smart education domain.

In a broad sense, mobile learning refers to the use of handheld devices such as mobile phones, laptops, Personal Digital Assistants (PDAs) and tablet computers in training, learning and teaching [3]. The authors in [6] define m-learning as "a dynamic learning environment through the use of mobile technologies especially in the field of education". The m-learning experiences cross spatial, temporal and/or conceptual borders and involve interaction with fixed technologies as well as mobile devices [7] which are very well suited for informal and self-directed learning scenarios. Mobile learning has the potential to help achieving educational goals and making the learning process more efficient and effective [8].

Mobile learning as a flexible learning approach has the strength of ubiquity, availability and increasingly diverse pedagogical effectiveness as well as technical functions such as geospatial technologies, social networking, sensors and radio frequency identification, visual search, image capture and audio recorder [9][10]. These advantages have encouraged educators to change the traditional way of teaching and learning and consequently to offer an active learning tool that integrates learning resources from the real world and the digital world [11]. Besides, mobile technologies enable users to participate in virtual learning activities and to improve their learning abilities without being tied to a fixed or a predetermined location such as school environment [12].

On the one hand, there is no doubt that learners have different needs, interest, knowledge, goals, experiences and background. On the other hand, the huge amount of information available on the web can quickly become overwhelming for learners and that makes them unable to efficiently select the necessary materials. Thus, helping students to avoid the cognitive overload has become more required by offering them an innovative learning experience tailored to their needs [13]. This situation has identified a common problem that differs from the traditional web-based learning problems, which is how to provide an adaptive and suitable learning that takes into consideration these differences and how to make learning processes more efficient and convenient [14].

We believe that the adaptive learning process is based on the mechanism of collecting, recording and analyzing learners' characteristics in order to understand their conditions, needs, preferences and to provide them with the appropriate adaptive learning resources and activities [15]. In

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this context, adaptive learning may be defined as "the process of generating a unique learning experience for each learner based on the learner's personality, interests and performance in order to achieve the learner academic improvement, learner satisfaction, effective learning process and so forth" [16].

Our research also aims to contribute in the field of adaptive mobile learning by introducing a model for diagnosing learners' context including their characteristics such as knowledge level, learning styles as well as their environment determined by the current location, their motions, physical activities, noise, etc. Our objective is to adapt the learning content and the learning format, both together in order to present the most appropriate and suitable learning to each student.

The rest of this paper is structured as follows. The second section presents an overview of the literature in adaptive mobile learning through analyzing the existing works and describing their limits in order to suggest our proposal. The third section introduces the general architecture and design of the proposed adaptive mobile learning system before discussing its components in details. Conclusion and future work are given in section four.

2. Related works

In recent years, there has been a lot of researches and practical contributions in the field of learning in the mobile environment. These works have presented the development of adaptive and context–aware m-learning applications for different educational objectives (learning foreign languages, learning in museums, learning general subjects, acquiring programing skills, cultural education, etc.). In this section, we present our literature review in the adaptive mobile learning systems and we point out the different characteristics used to provide the desired learning support as well as the limits of each work in order to introduce our proposal.

EduAdapt [17] application is based on the learner's current context in order to support the learning content and format adaptation. This model was implemented for mobile devices considering three groups of characteristics: learner profile, contextual information and device parameters. The learner profile includes personal information, academic profile, learning style, knowledge level, interests, preferences and learning objectives. Concerning the context-aware parameters, this application exploits mobile sensors to detect the location, time, learner's motions and his/her physical activities. The mobile screen size, battery level, multimedia and storage capacities as well as the network signal strength are also collected to determine the device parameters. This application verifies the learning object that matches with the user context and presents it in a given learning activity.

ALESS [18] is an adaptive navigation system for learning in museums. The learning approach of this solution is based on the process of collecting the contextual information in order to help students to learn in the real-world. The current location, the destination, the nearest learning target and the distance between the learner and the target are the main parameters used in the adaptation mechanism of this application. Besides, the time needed for each task, the importance of the learning targets and the distance between them are also taken into account to determine the suitable learning path. The application allows the user to choose, according the his/her needs, one of two navigation modes. The first one is navigation without learning guidance and the second is navigation with guidance using the adaptation mechanism.

CAMLES [19] is a mobile learning application for supporting students to prepare for the TOEFL test. The proposed solution, context-aware location-dependent learning, adapts the learning content according to the student's location, background, knowledge, preferences, concentration level, behavior and the preferred time interval to learn. As a result, it recommends the appropriate learning resources and generates the adapted test for each user. This mobile application is designed to provide learners with a simple interface for entering context parameters as well as detecting the learners' knowledge via an assessment test. Besides, the user can directly access a learning content without going through the adaptation process.

mTester [20] has been developed for different programs of study. This application aims to use the learner's location in order to present the appropriate learning format. It allows the learner to upload and review the courses in text format and to watch lectures through video streaming. In addition, mTester has a simple and intuitive user interface where the learner can take time-limited tests with the possibility of answering by audio recording. This functionality supports answering open-ended questions as well as questions that require extensive answers. It also helps students who find difficulties to express themselves properly by writing. A particular advantage of this application is the possibility for teachers to manage the different parts of courses and tests, to follow their students' learning activities and to control their improvement.

Context4Learning [21] is an Android application that offers the possibility to adapt the learning path in order to meet the students' specific needs and to achieve their learning objectives. This application makes the learner able to identify when and where he/she needs to receive notifications. For this purpose, the user's location, time and physical activities are used to deliver the appropriate notification. In addition to the student's context, it takes

into consideration his/her advancement level to make the learning activities available in a consecutive order.
i-Mol [22] is a multimedia-based mobile learning tool for English grammar learning. This solution aims to deliver personalized grammar learning contents. The main characteristics of this model are the students' profile, learning style as well as their mobility needs. The architecture of this application is designed for both Android and iOS platforms and it has the ability to exploit the SMS and MMS functionalities. In addition to this, the application supports giving feedbacks, receiving notifications and tips, getting reminders, participating in forums and game-like applications (ranking game, poll, quiz).
Another personalized and adaptive mobile application is developed and described in [23]. Its objective is to adapt the learning path of the computer-programming lessons. The basic learner characteristics used in this application are the student's knowledge level as well as his/her learning style. This solution mainly relies on a mechanism that builds connections between the units of each lesson in order to determine the learning sequences. In this way, the system generates the adapted learning path for each student and present it using three different formats: text, video and image.

Table 1: An overview of the existing mobile learning systems

Application	***Characteristics***								
	Knowledge level	***Learning styles***	***Behavior***	***Learning Progress***	***Satisfaction***	***Preferences***	***Location***	***Noise***	***Motions***
[17]	Yes	Yes	No	No	No	Yes	Yes	No	Yes
[18]	No	No	No	No	No	No	Yes	No	Yes
[19]	Yes	No	Yes	Yes	No	Yes	Yes	No	No
[20]	No	No	No	Yes	No	No	Yes	No	No
[21]	No	No	No	Yes	No	No	Yes	No	Yes
[22]	No	Yes	No	No	No	No	No	No	No
[23]	Yes	Yes	No	No	No	No	No	No	No
[24]	Yes	Yes	No	No	No	No	No	No	No
[25]	Yes	Yes	No	Yes	No	Yes	No	No	No
[26]	No	Yes	Yes	No	No	No	No	No	No

The research presented in [24] describes the development of an adaptive mobile learning application for information system courses. The main body of this model is the learner using his/her characteristics such as learning needs, abilities and learning styles. In accordance with these characteristics, the system adapts the learning content, learning strategies, learning flow and learning support. The application has a simple interface to take a pre-test that aims to measure the learner's initial abilities before starting any learning activity. After that, it allows to access the suitable lessons. The number and the type of questions as well as the test thresholds are determined by the teacher.
For cultural education, another personalized and adaptive learning system is introduced in [25] with various learning materials and activities. The adaptation in this solution depends on the learner's academic profile, learning style, interests, preferences, knowledge level, foreign language level as well as his/her learning progress and performance. The application is intended to adapt learning contents and paths, and it is designed in a way to be accessible by computers and mobile devices. It also makes the students able to check their learning progress, meanwhile, the teachers can follow their students' improvement through the system interface. Another option is receiving teacher's feedbacks as well as the correction of quizzes.
In [26], the authors present a framework that supports both desktop and mobile users. It is designed including an adaptive engine that generates suitable learning objects, based on the student learning style. Furthermore, it relies on an automatic learner modelling approach that detects and predicts the learner behavior. This is done through storing and analyzing his/her activities, say, number of visits, clicks and time spent on each course content. A particular advantage of this solution is a dashboard that allows the instructors to manage the course contents and to follow their students' behavior and learning styles.
EduAdapt supports the adaptation of the learning format depending on the learner's context, but it does not make good use of other mobile sensors such as the microphone to detect the environmental noise that may change the choice of the multimedia format. On the other side, the application aims also to adapt the learning content, but there's is no update of the learning progress during the use of the application. It only uses the knowledge level detected at the first login.
ALESS is designed to learn in museums, but it does not guide students according to their knowledge. In such case, it would be interesting to verify the learners' knowledge level and to update it by following his/her learning progress. Furthermore, it is widely recognized that the learning style as well as the learner's preferences are among the important characteristics that restrict the learning path, but they are not taken into consideration. Since this solution is intended to be used inside museums, it is advised to take into account the noise detected while using the application. As a good example, providing a learner with an audio for-

mat in a crowded museum (noisy environment) would not be the appropriate learning guidance.

In CAMLES, the location is not automatically detected. It is given as a predefined place (bus terminal, restaurant, outing, campus, home) where the learners use mobile devices to take part in the courses. Consequently, the learner can select a random location which negatively affects the effectiveness of the learning process. Additionally, it is known that the environment noise and the learner's physical activities are important to properly predict the learner's concentration level which is one of the basic features of this application. It is designed for a specific program of studies (learning English), but it can be improved and expanded to be a good solution for other programs.

mTester allows students to answer questions by voice recording. This advantage can be used in other situations, say, when the learner can not reply by writing the answer while he/she is walking or driving. This functionality requires taking into account the learner's environmental context using the detected noise and motions. This application enables the learning format adaptation, but it has been noticed that some significant factors such as the learner's preferences and learning style are absent. These factors are also important to be verified while answering by voice record.

Context4Learning and i-Mol offers different learning formats without any adaptation mechanism of this dimension. This could be possible by the integration of the learner's environment status (noise, motions) as well as his/her learning styles. In addition, there is no pre-test to estimate the learners' knowledge level which is a very important factor, not only to provide students with appropriate contents but also to monitor their learning improvement. Furthermore, i-Mol is completely based on one and only characteristic which is the learning styles and it creates groups of students for collaborative learning in a random way, without using common characteristics. It also uses SMS functionalities for all kind of content format which can limit the learning process if the adaptation engine generates a text format.

The applications presented in [23], [24] and [25] are designed to be used in mobile environments, but they did not consider the learner's mobility needs and they did not make a full use of the advantages offered by the mobile sensors, too. Concerning the learning styles parameter, the proposal in [25] uses a simple form to detect this characteristic, but it does not rely on a credible model. In addition to this, it has been observed that the authors in [23] deploy only the sequential/global dimension of the FSLSM model and ignore other dimensions (for example: visual/verbal dimension) that affect the different learning formats presented by this application.

The framework in [26] has a specific feature of using the learner's behavior, but it appears that the environmental parameters like the physical location and the learner's motions can make a big difference in predicting the learner behavior. Since this application aims to adapt the learning content, it would be more effective if it assessed the learner's knowledge level related to a specific topic and to update it by following his/her learning progress.

As shown above, we have studied and described ten contributions, so ten objectives were differently defined and successfully achieved. According to this analyze, it was found that each of these contributions provides a significant solution which is appropriate to a specific purpose. Nevertheless, there is a lack of a model that integrates all the parameters cited in table 1. This is because each model uses only some context and learners' characteristics and none of them has not yet paid considerable attention to an effective solution that delivers all the desirable functionalities.

In fact, the identification of the characteristics which effectively influence learning and which meet the learners' needs and requirements becomes the most difficult objective to achieve in the adaptive and personalized learning area. This is because of the huge number of characteristics as well as context parameters due to the continual improvement of mobile technologies. By reviewing the existing applications, it was noticed that most of them ignore the contextual parameters that directly affect the adaptation format and all of them do not use the mobile sensors to check the environmental noise. Others ignore the learners' knowledge level and its progress as well as the learning styles while adapting the learning content. Moreover, none of these models considers the learners' satisfaction which is a very important aspect that can drive them to stop using the application. It has been mentioned that only the solution proposed by [26] uses the learner's behavior which is one of the difficult parameters to predict, but it gives more reliability and efficiency to the application and it improves its performance. In brief, the determination of the factors that effectively build the learner model is a very important step in the development of an adaptive learning system. For this reason, this paper aims to propose a generic model that gathers the functionalities that have been mentioned above (table 1).

3. Presentation of the proposed system: architecture, design and components

"One of the focal points of student frustration with the curriculum is the disparity between learning (content) and the delivery of instruction (form)" [27]. In order to meet with this need, we present a system that integrates significant learner's characteristics, namely knowledge level, learning style, behavior and interactions with the system, learning progress, preferences and satisfaction. It also includes environment parameters, such as the location, noise detection as well as the learner's motions.

In this section, we describe the general architecture of our model (Fig. 1) before discussing its components in detail. As mentioned in our last research [28], any adaptive learning system's architecture is mainly based on three principal models: learner model, domain model and adaptation model. According the objective of this research, additional models are added, viz. application manager model, learners profile manager and context model. Each model is described as follows:

Learner Model: it establishes a map of the significant characteristics that are stored in the learner profiles database. It is one of the most important models which is designed, in our proposal, from the users' learning styles, knowledge, interactions with the system, preferences, learning progress as well as the academic and personal information. This component performs the learner modeling using the characteristics provided through forms and tests, together with the predicted behavior and interactions with the application.

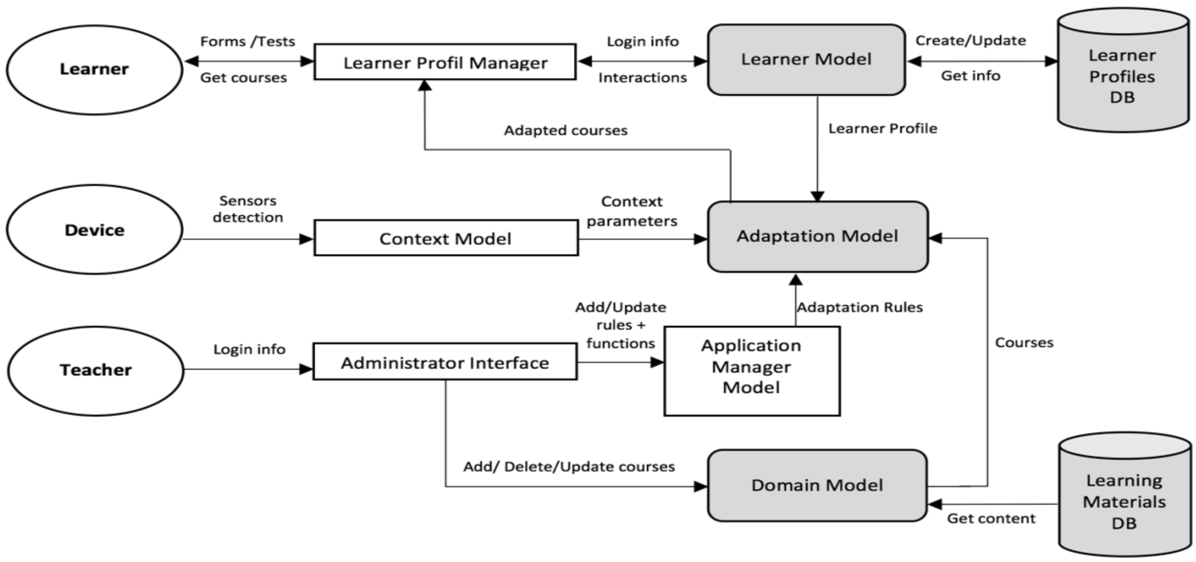

Fig. 1 Overall architecture of the proposed system.

Domain Model: it represents a structured representation of all learning materials (courses, tutorials, examples, tests), that are available in different formats, namely text, audio, video and image. These resources are stored in the learning materials database and updated via the administrator interface. It describes the hierarchy and the grouping of lessons, tests and their connections for each learning topic.

Adaptation Model: it uses the rules and functions indicated in the application manager module. This model represents the core of this application, because it collects the learner model data to generate the appropriate learning material imported from the domain model.

Learner Profile Manager: it detects the knowledge level via a given pre-test before taking part in each course. It collects learning styles using the Index Learning Styles questionnaire [29]. It follows the learner's progress through tests and quizzes taken by the end of each chapter. It also monitors the learners' satisfaction, interactions with the application as well as their preferences. At the end of each learning activity, collected characteristics are updated in the learner model and taken into account to adapt the next learning activity for the same user.

Context Model: it is a collection of the context values detected in real-time execution by mobile sensors in order to predict the learner's current environment situation, say, location, noise and physical activities.

Application Manager Model: it is in charge of providing and managing the instructions used by the adaptation model. The separation of these two modules makes the add and the update of the adaptation functions possible and flexible via the administrator interface.

Fig. 2 illustrates the three components of the proposed adaptive mobile learning system that we describe in the subsequent paragraphs.

3.1 Application/Learner Interaction Component

It represents the interface layer between the user and the system. The function of this component is to manage the operations executed between the learner and the system. It allows to provide other components with the necessary input to perform the adaptation process, including the learner characteristics and the context values. In addition, it is in charge of delivering the adapted learning objects to each user. It contains eight subcomponents described as follows:

3.1.1 Personal profile form

Each profile contains personal and academic information such as first name, last name, email, age, field of study and degree. These data build the static section of the learner model. At the first time the user manipulates the application, he/she is asked to fulfil a classical form in order to enter personal information that will be used for every learning session to perform the adaptation, unless the learner decides to change it or update it.

3.1.2 Index Learning Styles (ILS)

ILS [29] is a questionnaire (multiple choice test) of 44 questions created by Felder and Soloman that aims to evaluate the learner preferences through his/her answers. It is a data collection tool based on the FSLSM [30] and classified according to 4 dimensions : Active/Reflective, Sensing/Intuitive, Visual/Verbal or Sequential/Global. These dimensions respectively describe the variation of each learner's information processing, information perception, information reception, and information understanding. We choose the Felder and Soloman approach because it is convenient and widely used by the academic community.

Active/Reflective: Active learners (Activists) tend to work in groups, ask and discuss information with others. They are more experimentalist and understand best by practice. Reflective learners (Reflectors) prefer to work individually and they understand best by analyzing the information before practice. In accordance with this dimension, the application presents activities, examples and explanations first to an active learner before theoretical lessons. The order is inverted for reflective learners.

Sensing/Intuitive: Sensing learners (Sensors) like better to learn through facts and senses. They are more interested in details, practice and experimentations (laboratory work). Intuitive learners (Intuitors) prefer to learn (without repetition) through abstractions, broad knowledge and mathematical formulations. In our model, sensing learners are provided with further materials for more details. In the other side, intuitive learners receive overviews, abstract concepts and formulas.

Visual/Verbal: Visual learners remember best what they learn if pictures, videos, time lines and demonstrations are available. Verbal learners tend to choose the materials as written text and spoken explanations. This dimension is one of the most important characteristics taken into account for adapting the learning format.

Sequential/Global: Sequential learners prefer to go through the course step by step, where each step follows the previous one. Global learners grasp lessons randomly in unconnected chunks by getting the general concept and the main ideas first. In our model, sequential learners are provided with the learning materials in a predefined order, while an overview of each lesson is presented to global learners before explanations and details.

The four dimensions of the ILS allow to distinguish between eight different learning styles: ACT (active), REF (reflective), SENS (sensing), INT (intuitive), VIS (visual), VRB (verbal), SEQ (sequential), GLO (global). The questionnaire presents eleven questions for each dimension, therefore, the sum of two learning styles scores for each dimension is eleven. For example, if SENS score is four, then INT score is eight. In such case, the learner is an Intuitor. The final output of this component is a combination of four results of each dimension (for example: ACT/INT/VIS/SEQ) which is distributed to the learner profile manager to be used in order to build the learner model.

3.1.3 Knowledge test

The third subcomponent is the learner's background which is the most modelled characteristic in the majority of researches. It is estimated by taking a pre-test once the learner chooses to start learning a given course. In other words, pre-tests are generated in the beginning of each part of the educational courses. For this purpose, tests are created in conformity with the available topics and contents. We distinguish four categories of the learner knowledge level: new, beginner, medium and advanced.

3.1.4 Assessment manager

Since knowledge level is a dynamic characteristic, it is certainly required to update it to ensure its credibility and reliability. Therefore, at the end of each learning activity, the application offers an assessment test to check and to track the learner progress in a particular topic. The objective of these tests is to estimate the learner's knowledge in a given topic and to update the value calculated before the corresponding learning activities. The thresholds are determined by the teachers to decide whether the learner is able to obtain the following chapter or not.

3.1.5 Satisfaction form

The learners' satisfaction can influence the learning process negatively if the content or the format offered by the application do not adequately meet their needs and expectations. In such case, we afford a form in order to collect and investigate what decrease their satisfaction and motivation. The form includes different questions related to the learning content and format, for example, if the learner indicates that the format of presentation is not suitable, then we can predict that maybe the ILS was randomly filled. Consequently, the learner could take it again to update the learning styles.

3.1.6 Preferences form

The learner preferences in our model are related to the text format. Whenever the text format is generated, the application takes into consideration the learner's favorite color, font size, page layout as well as the favorite foreign language.

3.1.7 Behavior detector

The learner's behavior or the learner's interactions can be predicted via the collected data from the application log files and reports in order to get more accurate information about the learner. The system detects the frequency of accessing the application (rarely, sometimes, frequently and always), number of clicks and time spent on each learning content, particular activities, specific course or on the application in general. This functionality allows to predict the learners progress as well and that could automatically update their knowledge level.

3.1.8 Context values component

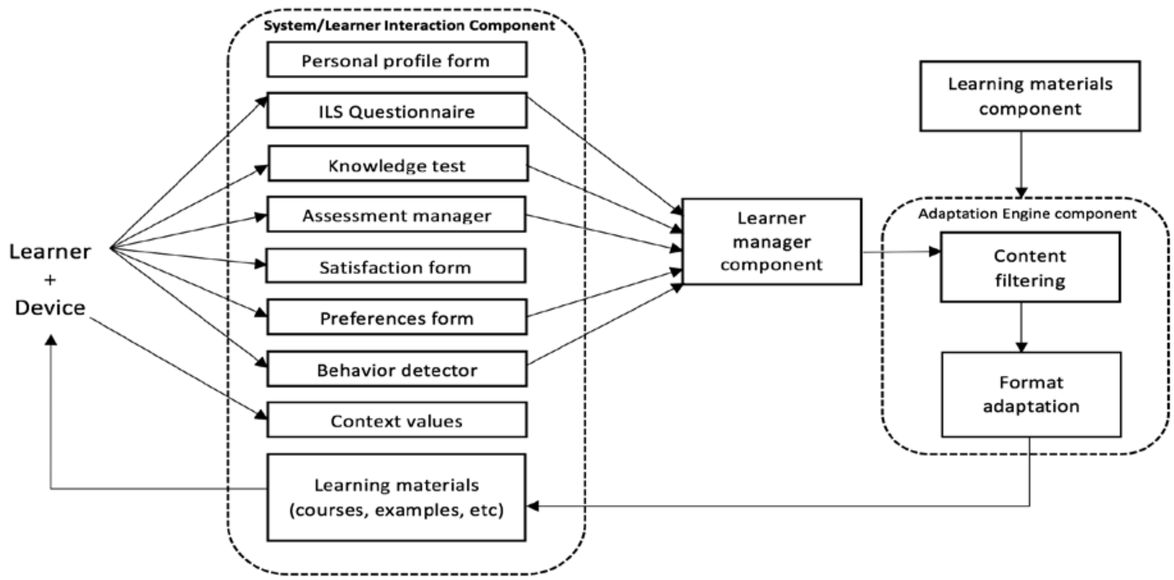

Fig. 2 Application's components.

This subcomponent includes the information related to the current environmental situation of the learner. First, the current location is detected by the GPS sensor in order to determine where the learner manipulates the mobile device to participate in the courses. It includes geo-spatial information of the learner location and the frequent sites. Second, the learner's physical activities and motions are determined by the accelerometer sensor. As a result, the learner could be in a state of walking, running, driving, sitting, standing, etc. This feature has a direct impact on the learning format, say, text format is more suitable if the learner does not move from a place to another during the learning activity. Third, the noise detected by the mobile microphone is also required to indicate whether the learner is able to listen to an audio, to watch a video learning object or not. The gathered context parameters are taken into consideration to properly recognize the learner's context and circumstances to be used by the adaptation engine.

3.2 Learning materials component

The learning contents are arranged in a hierarchical structure (tree) as shown in Fig. 3. The summit of each tree represents the main discipline and the child nodes are classified in four levels, viz. subjects, courses, chapters and learning objects. Strictly speaking, every subject consists of different courses which are divided into various chapters.

Each chapter contains a set of learning objects which are composed of several contents, attached examples and illustrations. Each node is characterized with specific attributes which are verified at the first step of the adaptation process in order to identify the learning objects that meet with the learner's need. This selection decision depends on the test knowledge result which exactly indicates the learner's weaknesses as well as the lesson segments and depth that are required. Finally, each learning object is available in audio, text and video format. The appropriate format is

selected by the format adaptation function integrated in the adaptation engine.
Concerning the assessment tests, a set of quizzes and tests are stored in the learning materials database. In order to present the appropriate quiz after a determined learning activity, each test refers to a well-determined chapter and each question refers to a well-determined concept in a particular learning object. Consequently, the test results indicate the concepts that the learner has assimilated. In such case, the application presents the following chapter, else the learner should study the same chapter once more.

3.3 Learner manager component

This component builds and manages the learner model by collecting the required data about the user's characteristics and information via the ILS questionnaire results, knowledge tests, personal profile form, satisfaction and preferences forms, assessment manager, behavior detector and context parameters. The first time the learner joins the application, an initial profile is created based on personal and academic information, preferences, learning style and knowledge level related to the selected topic. Each learner profile is updated after a post-test to assess the knowledge level and a satisfaction form to predict what should be changed to motivate the learner. Moreover, the behavior detector provides the learner manager component with the required information that help to give a reliable learner modeling. On the other hand, the dynamic context parameters are updated every time because of the learner mobility and they are taken into account by the learner manager component to combine all the necessary features. Finally, learners may change the static information (academic and personal information) at any time. This change is performed via the Learner/System Interaction Component which operates the user profile on the device side in order to update the learner model in the server side. All these characteristics are transmitted to the adaptation engine to achieve the application's goal.

3.4 Adaptation engine component

The adaptation engine receives the learner context (input) and generates the adapted learning content and format (output). It is in charge of performing the mechanism of adaptation by communicating with the learner management component to get the user profile, learning materials database for courses as well as application manager model to obtain the adaptation functions and rules. This mechanism consists of two stages, namely content adaptation and format adaptation described as follows:

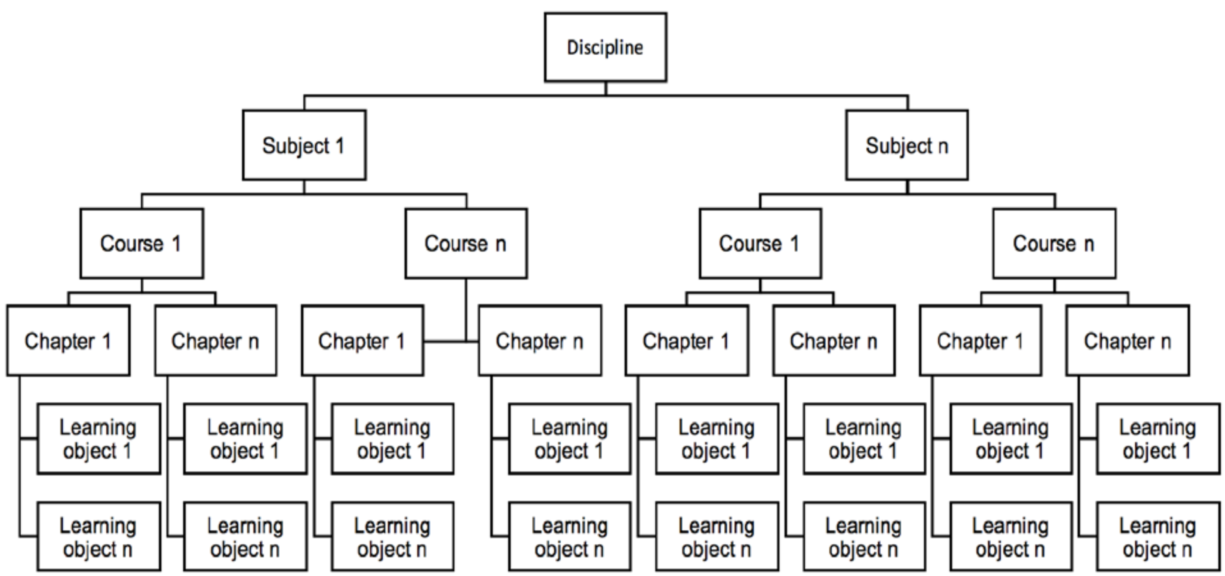

Fig. 3 Hierarchical structure of the learning content.

1. Content adaptation: Once the learner selects a topic, the adaptation engine starts checking the existing learner knowledge and learning styles that will be used as a basis to select the suitable learning objects when the learner uses the application for the first login. After the first learning activity, the engine starts taking into account the test results that update the knowledge level in order to achieve the content adaptation goal of this stage. Moreover, the learner's interaction with the application are delivered to the adaptation engine to predict the learner's preferences towards the content.

2. Format adaptation: Once the learning content is selected, it needs to be presented according to the leaning styles, preferences and context parameters. The learner satisfaction in term of format of presentation is identified at least after the first learning activity and it is taken into account in the following adaptation process. This stage occurs when the segment of the learning object has been determined so that it chooses only the suitable presentation of the corresponding content according to the factors that affect this choice.

After performing the adaptation process through the rules given by the application manager module, the adaptation engine communicates with the learning materials component to receive the determined learning object. After that, the learner gets the adapted content and format that he/she needs via the learning materials interface.

4. Conclusion and perspectives

This paper has reviewed at first the literature and the existing adaptive mobile learning systems. As a result, it has been noticed that none of these solutions has combined the most important learner characteristics with his/her environment parameters in a way to effectively establish the learner context. We have selected a set of characteristics and features that we consider pertinent to understand each learner needs and abilities in order to deliver the most appropriate learning resources. Furthermore, our model is not limited to a particular field or program of studies, in contrast to the applications for learning in museums, foreign languages, programming skills or cultural education.

In fact, mobile and digital technologies kept growing tremendously to satisfy all kind of users. In today's competitive and globalized world, mobile devices can be viewed as a newer key to provide flexible and innovative applications, well-designed learning environments in which students have become active and interactive learners as well as an adaptive learning which is "just enough, just in time, just for me" [31]. We have also to be in line with the modern-day generation that requires to move towards mobile learning in order to make a good use of the offered opportunities that support adaptation goals. In this context, our proposal intends to analyze and understand learners' characteristics, to predict their current situation and to track their improvement and interactions in order to deliver the adapted learning materials in a dynamic way.

This contribution is still in progress. Future work will deal with the adaptation engine describing in details a new process and mechanism of adaptation. It will present the development and the deployment stages of the application and it will show the evaluation results. It is hoped that our work will be able to open the door for a series of significant contributions that can be able to positively influence learning in various programs and disciplines.

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