Designing a Theoretical Integration Framework for Mobile Learning

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Abstract—New technologies are rapidly changing mobile learning and making it difficult to control. In addition to educational factors and learning content, a modern mobile learning system must take into account the technical and personal aspects of learning, the devices and aspects related to its evolution and interoperability. Teaching on the other hand has also evolved involving more flexibility in tasks and learning stages, thus using modern technologies that offer more alternatives now. In addition, such tasks may be specific to the learning content as well as the learning context or furthermore the learner's environment. Traditionally, mobile platform design relies on the skills of a mobile developer whose knowledge allows him to design mobile applications that are useful to users. But with mobile learning, the design phase involves more than just mobile development skills. For example, if you are designing a platform for practical work, the instructors responsible for the training should be involved. However, the empirical results show that educators do not integrate technology effectively into their curricula. To enable these instructors to develop mobile learning platforms, it is important to facilitate their integration through a theoretical model that will take into account all the ingredients necessary to complete this learning and to balance them in order to ensure its efficiency. In this study authors used a thematic synthesis methodology to present a framework for mobile devices integration in learning. They focused on three models that they think are the most cited in the field of ICT (information and communication technologies) integration in learning. The five-axis framework consists of enriching the TPACK framework (Technological Pedagogical Content Knowledge model in order to more precisely address mobile learning by covering the following parts: pedagogy, content, mobile technology, learning environment and learner's profile. It describes relatively in depth the various factors involved as well as the effective interconnection to be ensured to achieve an optimal and efficient integration of m-learning. Balancing those five parts will be a matter of plural reflection when designing or consulting on a mobile learning platform.

Keywords—Mobile learning, frameworks, integration model

1 Introduction

As its transcending all aspects of learning, mobile learning has been defined differently by researchers. Shorten in the literature as M-learning or mlearning, it represents any kind of learning that occurs when the learner is not at a predetermined fixed location, or learning that occurs when the learner takes advantage of the learning opportunities offered by mobile technologies [1]. Many important opportunities are provided to users through mobile learning as ownership and personalized control of learning process, learners are more comfortable with their own mobile device and less preparation is needed for learning [2] [3]. Despite all these advantages, there is major empirical evidence proving that mobile learning has been poorly used in many education sectors and research have tended to be more centered about the technical aspects of the tools and applications than of the learning approach itself. Integration frameworks for mobile learning will enhance its usage, taking to account all aspects of this learning method including learner's perception about it.

This paper investigates different theories and scientific evidence of technology integration in learning to present an m-learning integration framework. First, a brief exposition of the two major scientific current of mobile learning definition is presented followed by a review of technology integration frameworks in general then the ones centered specifically on m-learning. While acknowledging all identified features in other frameworks as important in mobile learning, an enriched model based on the TPACK framework is proposed highlighting a new unique combination of distinctive characteristics of current mobile pedagogy to bring a more detailed insights to the literature on m-learning. As a conclusion a Webview rendering architecture is finally presented to explore the potential experimentation of this theoretical framework.

2 Background

Several descriptions of m-learning are present in the literature, but they all take into consideration the close link between the use of mobile devices and learning: the learning process mediated by a mobile device [4]. M-learning can be identified for this paper as a method of learning that enables learners to access learning materials anywhere and anytime using mobile technologies and the Internet [5] [6] [7]. However, how to integrate these devices into learning is a thorny issue [8].

Designed to make it easier for those planning to integrate mobile applications into higher education MIT has developed the MIT mobile framework for educational institutions [9]. Moodbile is also a framework helping integration of multiple learning applications into learning management systems [10]. As valuable and informative as they are, these frameworks focus precisely on the integration of technology into other technological systems and not on broader aspects such as educators, learner profiles or contexts of learning.

Many researchers [11] [12] [4] have used activity theory to analyze individuals' development practices and processes, while considering individual and social influences in the use of mlearning. Uden has developed a framework for mobile application design for mlearning. While drawing partly from Vygotsky's work on mediation and the proximal developmental area, Koole has designed the Framework for the Rational Analysis of Mobile Education (FRAME). The work of Kearney et al extends Koole's framework, including an understandings of "mobile pedagogy", which is based on the socio-cultural understandings presented in her model. For instructors, these frameworks do not offer a solid support considering how they should proceed with integrating m-learning into the curriculum.

In line with the work done in the field, we have been interested in the general frameworks for the integration of technology into learning as a base of work. Three initial frameworks have been identified for further study: the Technological, Pedagogical, and Content knowledge (TPACK) framework by Mishra and Koehler [14], the i5 framework by Groff and Mouza [13] and the Substitution, Augmentation, Modification and Redefinition (SAMR) framework by Puentedura [15].

3 Integration Frameworks

3.1 The i5 framework

Essentially at the origin of this framework, Groff and Mouza (2008) discussed six central factors with their different variables. These factors interact with each other creating barriers to the successful integration of technologies into learning. The factors are:

- Research and policy factors
- Department / school factors
- Factors associated with the teacher
- Factors associated with the enhanced technology project
- Factors associated with students
- Factors inherent in the technology itself.

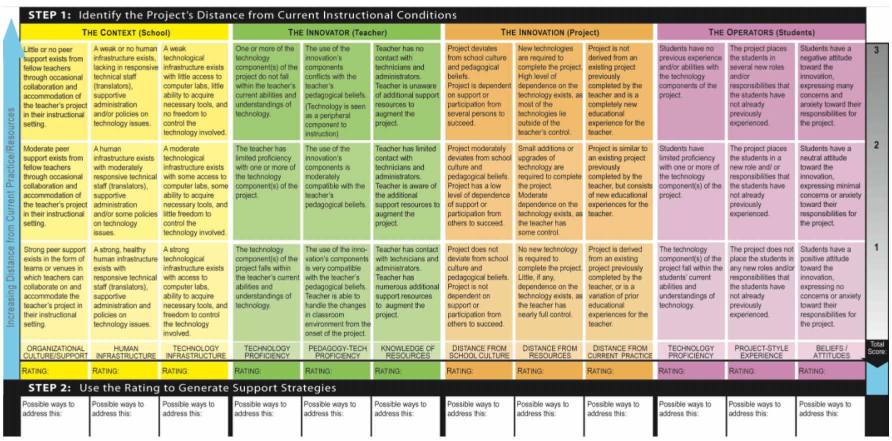

Fig. 1. The i5 Framwork by Groff and Mouza (2008)

The authors of the model explain the teachers' inability to handle all these factors, although they are all important. So, they focused on the four factors that can be influenced by instructors through their i5 model which is a tool to help the mainstreaming of technologies in learning.

3.2 The SAMR framework

The SAMR model is schematized according to four main layers with two margins of evolution of learning. The first is a margin for improvement of the learning practice, with two layers (Substitution and Augmentation). At this level the technology is integrated to replace an old method without changing the functional aspect of the activity or improve the practice using the ease of technology introduced. The second margin is a transformation phase of educational activity. Indeed, represented in two layers (Modification and Redefinition), the learning activity is transformed this time through technology by changing its conceptual nature or by allowing the accomplishment of an entirely new tasks, inconceivable without the integrated technology.

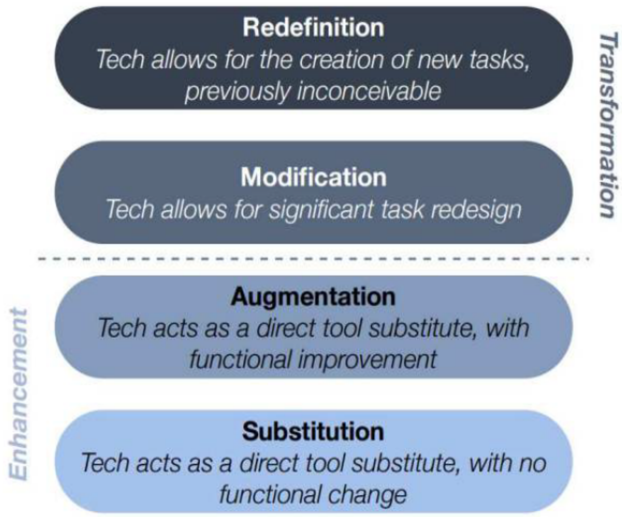

Fig. 2. The SAMR Framework by Puentedura (2009)

3.3 The TPACK framework

Based on the model of Shulman, the TPACK framework "the Technological, Pedagogical, and Content Knowledge" by Michra and Koehler, presents three circles instead of two in the original model. The first two circles being pedagogy and content, Michra and Koehler have added technology as a facilitator of learning. Interactions between and among these bodies of knowledge are equally important to the model, represented as PCK (pedagogical content knowledge), TCK (technological content knowledge), TPK (technological pedagogical knowledge) The three circles need to interact collaboratively to enable effective integration of technology into learning

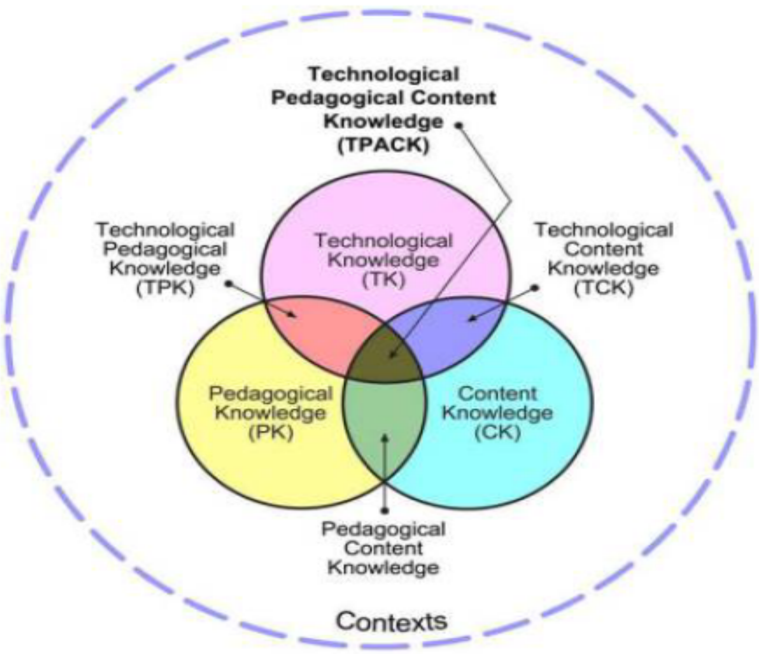

Fig. 3. The TPACK Framework by Michra & Koehler (2006)

Since its first publication in 2006, TPACK has become one of the most powerful theories in technology integration in education as the complex components described above remain open to a large range of educational circumstances. The flexibility of this model can be visible in the multiple junctions of its spheres allowing researchers to adapt it to various contexts and cases.

4 Methodology

In order to conceive our new m-learning integration model, authors adopted a thematic synthesis which allowed us to prioritize the transversal data collected previously through a manual search, including terms such as "mobile learning", "m-learning", "m-learning framework", "ICT integration", "technology in learning". Inspired by the method in Ref [16] and in the same scope of Crompton's work on mlearning integration frameworks [17], the researchers proceeded in three steps explained below:

- First, authors identified the different themes and fields of our research from the studies collected before. Subsequently, they translated these results into a transverse metric. At this stage the codification is rather descriptive but still similar to the texts previously contained in the studies reported. Next, they used support software for qualitative and combined research methods

- The second step consisted in organizing the identified thematic codes into descriptive themes in order to "develop and articulate relationships between the themes and associate conceptually similar themes with one another" [18]
- The last step was to generate analytical themes. At this stage, the synthesis has crossed the limits of the initial content of the original studies proposing new perspectives and conceptualizations

5 Findings and Discussion

The thematic synthesis made it possible to identify new associations and conceptions between the different frameworks that we studied and considered as an entry into our new mobile learning integration framework. The framework proposed below is an enrichment of the TPACK model also inspired by Koole's in [12] and Kearney et al.'s [4] frameworks insofar as the close interaction of the new spheres identified can be considered as an efficient integration of mobile technology into learning.

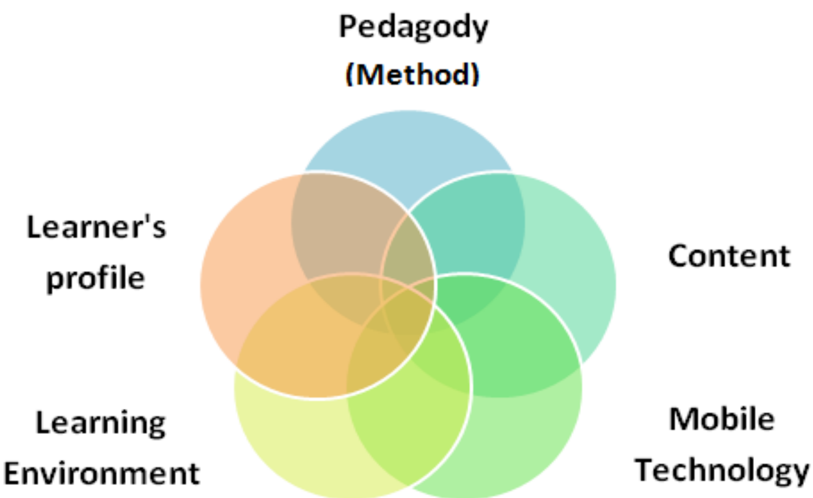

Fig. 4. The 5 axes m-learning integration framework

5.1 Pedagogy: Method

Mobile technologies can enable the development of innovative pedagogical practices such as student-centred pedagogies as well as several communication and problem-solving skills along with critical thinking skill [19]. The teaching method is the starting point of this 5 axes mlearning integration framework. With its influence on all other factors, the teaching method will guide the choices of an m-learning platform as well as the required levels of quality and performance. All means will decline themselves in service to this major factor to ensure the homogeneity of the platform with the educational purposes behind its design. The pedagogical method represents the way in which learning will be conveyed, for example: collaborative learning, problem-based learning, experiential learning.

Laru insisted on pedagogically grounded instructional design to turn mobile technologies into effective tools for learning and collaboration [20]. The examples of mobile learning related to theories of learning are exposed in table 1 below [21].

Table 1. Theory-based examples of mobile learning practices (rikala, 2015)

Theory	View of the Learning Process	Examples with Mobile Technologies
Behaviorist	Change in behaviour and observable actions facilitated through the reinforcement of a specific stimulus and response	Drill and feedback activities/classroom response systems
Cognitivist	Learning results from organizing and processing information effectively	Performance support
Constructivist	Learners actively construct new ideas or concepts based on both their previous and current knowledge	Approaches like experiential learning, participatory simulations, discovery learning, collaborative learning, situated learning mediated bu mobile devices
Humanistic	A personal act to fulfil potential	Self-directed learning
Connectivistic	Connecting, navigating and filtering specialized nodes or information sources	Social networking and media creation

Educators should be totally aware of the consequences of their choices in this stage. All pedagogical methods don’t fit necessarily all contents or even all learners [22]. This sphere should be considered wisely along with the two adjacent ones in the process of designing new forms of teaching and learning through mobile technologies [23].

Nevertheless, another important factor at this level is the readiness of instructors to embrace the mobile technology as a tool for learning not just a support for learning's content. Instructors who are not familiar with mobile technologies will not be able to conceive learning activities through it or at least effective ones. The pedagogical method adopted in mlearning platforms should be open to adaptations through the progress of designing all the spheres even if it's the main influence on the global conception.

5.2 Content

In this sphere, the same considerations of TPACK framework are noted. Content is the material intended to be taught to the learners, it must be compatible with the learning policy as well as the means made available. For instance, middle school courses are very different from undergraduates. Same as subjects of these courses, teaching science is very different from arts or history. The knowledge levels, theories and practices are designed differently.

The pedagogical content knowledge by Ref [24] covers much of the considerations at this level. It addresses "the core business of teaching, learning, curriculum, assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy".

From a basic or traditional content to a scenario or practical laboratory work, the teaching subject generates considerable design choices that can sometimes be a hindrance to integration. However, standardization of similar content can be a valuable asset to integrating technology into learning. This circle is generally thought and stopped at the same time as that of the teaching method in order to conceive strong relations and interactions guiding the other considerations for platform design.

5.3 Mobile technology

For its part, technology is the nerve of the expected system. By seeking to integrate it in an optimal and reasonable way, the technology must be well thought out and well framed. Especially with mobile technologies, making full use of its great potential for flexibility and ease of use is very delicate, which can sometimes be perceived as a complicated task by the instructors and automatically delegated to the technology specialists who will then always be consulted for platform administration and technical design. It is very important to mention that this sphere comes after pedagogy and content design. Educators have to first think about a quality course plan and then identify the mobile technologies to support that course. The use of mobile devices should not be the main purpose of the sessions plan; instead, it should be a good tool for making it work [25].

Wang, Wu, and Wang indicate in Ref [26] that mobile learning platforms should be user-friendly, easy to use, and intuitive to be appropriate, engaging, and accommodating to learners. Even their motivation can be frustrated if they encounter technological problems or if they are not attracted enough by the platform [27]. As observed by Ng and Nicholas in Ref [28], students became less engaged and excited. They thought that mobile technology didn't help them learn better or facilitate learning or even made it more interesting. The researchers find that students' statements about the effectiveness of a mobile learning program decreased between the start of the program and 12 months later.

In a way, the technology in general in such platforms guarantees the level of quality that will be presented to educators and learners. However, mobile technology is now experiencing a remarkable growth in terms of innovation which implies a complexity also for the design of mobile learning platforms. A multi-criteria analysis and advanced comparative study between M-learning development approaches was conducted before which can be of a great help to instructors [29].

To summarize, this circle encompasses all the technical part of the systems namely the platform architecture, the mobile development approach and the extensions and technical features.

5.4 Learning environment

The fourth factor that comes into play is the learning environment, which is all aspects of the learning context. This term is very important to note in a mobile learning, since it is an integral part of the identity of the latter. We share the same definition presented by Dey in Ref [30] concerning the context which is «any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves». However, other terms are also at the same level of importance and must be considered equally namely time and space, after all they are the main elements that constitutes the context. Kearney et al. in Ref [4] placed the use of time and space at the centre of their framework, shedding light on several interesting interactions of collaboration, authenticity and personalization. But they also focused on context same as Koole in Ref [12] did, highlighting it in her FRAME model; she think that mobile learning experiences happen within a context of information. A dynamic context that encompasses primary, secondary and higher education or corporate learning environments, as well as formal and informal learning to classroom or distance learning and field studies [31].

According to Rikala in Ref [27] Mobile learning can expand the learning environment meaningfully into authentic contexts, but "the challenges in creating a mobile learning environment may lead to situations in which the devices are employed only for enhancement-level usage where a computer, booklet, or handout is replaced with a ready-made application". He stated that decisions concerning the learning environment can have direct influence on the formality and spontaneity of learning experiences. Chu in Ref [32], for instance, argued that mobile learning in authentic contexts is not always a great success. He thinks it is important to design different learning strategies and to invent new ones that consider the particularities of mobile learning.

Learning environment constitutes the core of a platform design that's what make its creation challenging. laru's study in Ref [33] highlights several important elements for the success of a mobile assisted collaboration and the first of them is the careful design of the learning environment for group interaction, the second is the provision of scaffolding and also support from educators. Mobile learning platforms can offer a variety of services; therefore coordination is crucial, linking different contexts and optimizing learning. Big part of that is initiated through context-awareness.

Schilit, et al. in Ref [34] introduced first the term "context-aware", they think that context-aware applications can simply adapt to the context. Byun and Cheverst in Ref [35] define it as a system that can extract, interpret and especially adapt to different contextual information. Generally in literature, context-aware is mentioned as context-sensitive, situated, contextual, adaptive, located, etc.

5.5 Learner's profile

Part of the bigger picture that is learning context, the learner profile is a key element of context consideration. This last circle can be considered as an extension of the previous one thus closing the aspect of the context in its entirety. The learner profile falls into the second category of learning context modelling, being divided in general in two parts which are the learning context and the mobile context [36]. The learner profile may include and is not limited to [37] [38]:

- The competency profile of the learner: with all the knowledge, skills and possible attitudes, role
- The semi-permanent personal characteristics of the learner: containing the learning style, the different needs and potential learning interests, physical disabilities or other personal aspects

Yau and Joy in Ref [39] proposed a personalized mobile learning application based on m-learning preferences where learner profile consists of an initial simple questionnaire which is generated on one-time basis for learners before they commence with their learning activities in order to get their m-learning preferences. Data are stored into the application and an option to change preferences is allowed although generally they are more likely static and set all for once. They adopted three main preferences to be considered as inputs, namely location of study, level of noise/distractions and the time of day. All of them will be appreciated based on three levels (strong, medium or weak) describing the learner feelings towards them. The questionnaire conducted in their study were very similar to Felder and Silverman in Ref [40] and Honey in Ref [41] learning preferences/styles questionnaires designed to return the learning styles of learners prior to the use of mobile learning or web-based applications.

Personalization mechanisms are one of the main considerations at this stage also. The latter makes it possible to manage features such as self-regulation, personalization of content, learner's choices and tendencies. This concerns can be found in both [12] and [4] frameworks.

6 Experimentation

To further examine the efficiency of this new framework, system architecture is proposed to help adapt an existing LAMS (Learning Activity Management System) platform to the mobile environment through this latter. As an integral part of an LMS (Learning Management System) generally, these systems can very well run separately too. This type of platforms allows building interactive game-informed content, educational activities and simple educational games. This experimentation will be hosted as an R&D project of Mohammed VI University of health science since they expressed their real need to change the old way of clinical reasoning teaching and learning.

The main objective through this experiment is to validate the new framework for mobile learning integration through the evaluation of its effectiveness to support creation, adaptation and improvement of mobile learning platforms. Exploring new fields of exploitation of mobile technologies in learning is also part of this experiment. Throughout the period of research, mobile learning was rare or poorly stated on literature addressing healthcare sciences learning. So that concern motivated this experimentation also to enrich that field of research.

6.1 Why a LAMS and not LMS?

Simply because the idea of adapting and integrating mobile devices and educational applications with an LMS has already been explored [42], and since they have practically similar architectures, the idea of mobile adaptation for LAMS presents more interesting challenges to such a mobile implementation.

6.2 OpenLabyrinth

Our choice fell on a very interesting platform called OpenLabyrinth, which is an online Activity Management System that allows users to create interactive and informative educational activities, such as virtual patients, simulations, games, mazes and algorithms. It is mostly compared to a flexible online story, similar to the Choose Your Own Adventure style of book. Depending on the decisions the learner makes or the path he or she chooses, the consequences will be different.

Launched at the University of Edinburgh in 2004, the project OpenLabyrinth aimed to change in a way the expensive and cyclical development of computer-based learning packages using tools such as Flash, Adobe's Director and Authorware. The main purpose behind it was to design an intuitive and easy to use tool, capable to support as many types of case-based activity designs as possible requiring minimal time for new case-based activities development [43].

This LAMS offers very elaborated functionalities like a visual editor of virtual patient case in the form of a labyrinth which schematizes the different potential paths for the learners, and like an LMS, OpenLabyrinth offers authentication as well as a discussion forum and several other components.

6.3 Method

Having the web-based version submitted to tests by administrators, educators and learners. Data was collected through a post-survey and interviews to identify specific needs for mobile adaptation design. The results were aggregated into several considerations, which were then integrated based on the 5 axes m-learning integration framework into a system design to form mobile-based adaptation. The steps followed in the research model of the Mobile Clinical Cases Learning System included:

Pedagogy (Method): Virtual scenarios are core concept of the OpenLabyrinth platform. Based more generally on a sort of PBL (problem-based learning) evolution, SBL (Scenario-based learning) is a complex combinations of learning experiences, resources and tools constructed in a specific way in order to address the learners' needs. Typically, scenario-based learning (SBL) can be defined as support of active learning strategies such as problem-based or case-based learning through interactive scenarios. Learners will choose an individual path through an ill-structured or complex problem that should be solved. They will feel the real-world context through a well designed storyline in which they have to apply their problem solving skills, prior knowledge of the subject and critical thinking. Many feedback opportunities and hints will be provided depending on the decisions they will be making at each level in the process.

Content: It had to be clear that OpenLabyrinth can tackle and explore any educational problem and not just virtual patients. However, virtual patients will fulfil the need expressed by the great majority of educators and learners interviewed as mentioned before. In this case study, virtual patient will replace the old way of teaching clinical reasoning which was a classic power point. Another work of collection and adaptation to the platform was performed with the help of educators to help designing scenarios. A virtual patient is "an interactive computer simulation of real clinical scenarios for the purpose of training, education or medical evaluation" [44]. Many designs are possible through the platform, however two of them are the most common and powerful when it comes to healthcare science teaching and learning namely: linear and branched designs. For instance linear designs can facilitate medical protocols learning while branched ones could enhance clinical reasoning throughout advanced complexes scenarios. Three themes are mostly chosen to deliver virtual patients designs; storytelling, simulation and gaming. Storytelling allows learners to explore roles and patterns, which progresses over time. As for the simulation, it ensures grounding in real context. Gaming manages the means by which virtual patients offer to learners the possibility to try different strategies to solve the case respecting a well-defined set of rules.

Mobile Technology: At this stage more freedom was possible considering the survey results early mentioned. although, three large considerations had to be respected for the design of the mobile application to meet the initial expectations namely ease of use, interoperability and full access to all or the majority of the web-based features of the platform. A multi-criteria analysis and Advanced Comparative Study between M-learning Development Approaches was conducted before, helping instructors choose between native, web and hybrid development [29]. The better scoring approach will be used for this mobile adaptation which is hybrid conception. Considered as one of the most powerful frameworks ionic v2 was used to develop this application. Future administrators of the platform proposed that design of the application should be very simple since it's just an adaptation for mobile and not a complete conception. So a decision was made to keep everything as it is on the web based and design a webview simply that will be rendering the content and making it easy to encapsulate navigation through the platform for different mobile operating systems. Architecture below explains the approach adopted for the Mobile Clinical Cases application.

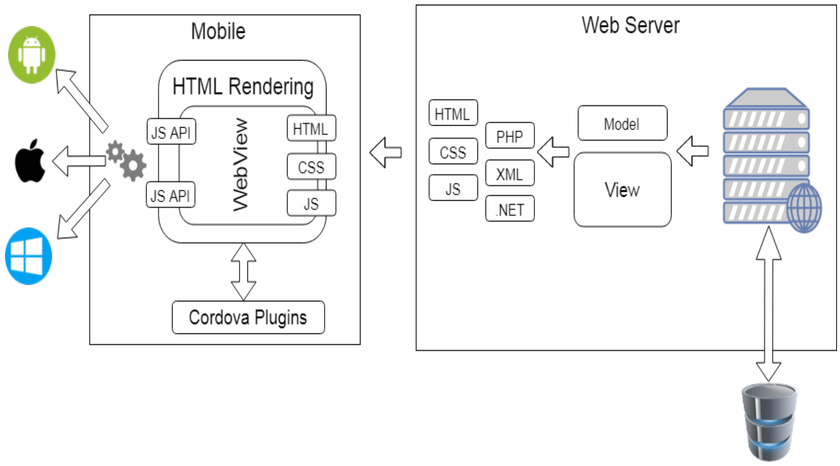

Fig. 5. Architecture of the Mobile Clinical Cases application

Learning Environment: The historical context for teaching clinical reasoning has been a major point of divergence at this level of design. Being less skilled in ICT manipulation, a large part of the educators supposed to become referents of their virtual patients cases were rather sceptical for a formal adoption of this type of learning. They were not comfortable to switch directly to learn with the application on class, they were discouraged when they discovered the huge efforts they will be making to adjust their old power point presentations, also some of them were simply not ready to change their way of teaching. In the other hand learner's were very enthusiastic to embrace this new way of learning, especially when they discovered that pathways are different for each player and that they can play the cases as much as they wish. The idea of discussing the cases on the forum was a very positive point too. The final decision was made to keep the learning informal at least for a testing period and maybe adopt it formally later for fifth year medical students and third year of nursing as a tool to keep their knowledge updated when they are on clinical rotations. All context-awareness aspects will be handled later on as an improvement process of the platform, after gathering enough data. Source code will be enhanced on server side and new distributions of the application will be offered as simple upgrades for users.

Learner's Profile: As stated above, it was decided to target medical students as well as nursing students. Considering the differences of knowledge levels as well as the personalized content for each profile, the management of the learner's profile is already present on the server side mostly on a standard manner (classic authentication with login and password). Many categories of profiles are presented for the administrator to choose from, offering specific access for each learner. Groups can be formed and assigned a number of virtual patients, tracking results is then possible for all groups separately. Part of the future upgrade will address learner aspects considering context-awareness.

6.4 Results

Directly after authentication, users land on the home page shown in figure 6 which can give access to all the other pages: List of public and assigned cases, management of the profile, Forum & discussion, personal collection of VP cases, Scenarios assigned.

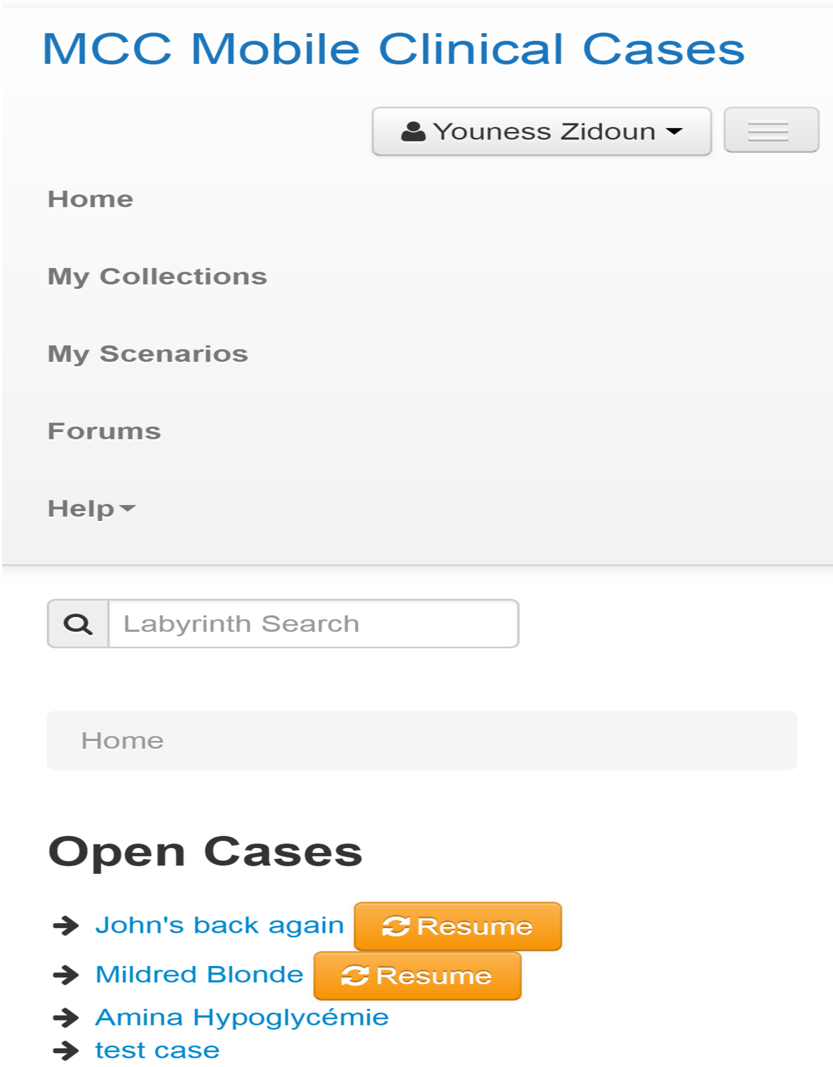

Fig. 6. MCC Home page

The mobile clinical cases application offered a new workflow on the platform. The first step in this learning process is the creation of the different user profiles by the main administrator. Then, referring authors create cases and build content with all the necessary resources, such as CT scans, blood tests, multimedia. Administrators as well as referring authors have the right to create new cases, edit respective data and delete them. Authors although, have only permission to display data of their own cases. The case may also represent a scenario (set of cases), which may include several related learning topics. Learners assigned to different cases individually or organized in groups can start the scenario only after completing the pre-test. Then, they play the case until the final result of their clinical reasoning by making a precise diagnosis of the case. The discussion forum remains accessible to those who have not passed the pre-test to discuss and collaborate on the case and the concepts discussed in it. Finally after finishing the post-test which is approximately same as the pre-test, learners can check the summary of their decisions on the entire pathway and the feedback of the quiz in order to improve their skills on the subject the next time. Figure 7 show this new workflow while figure 8 presents the navigation diagram.

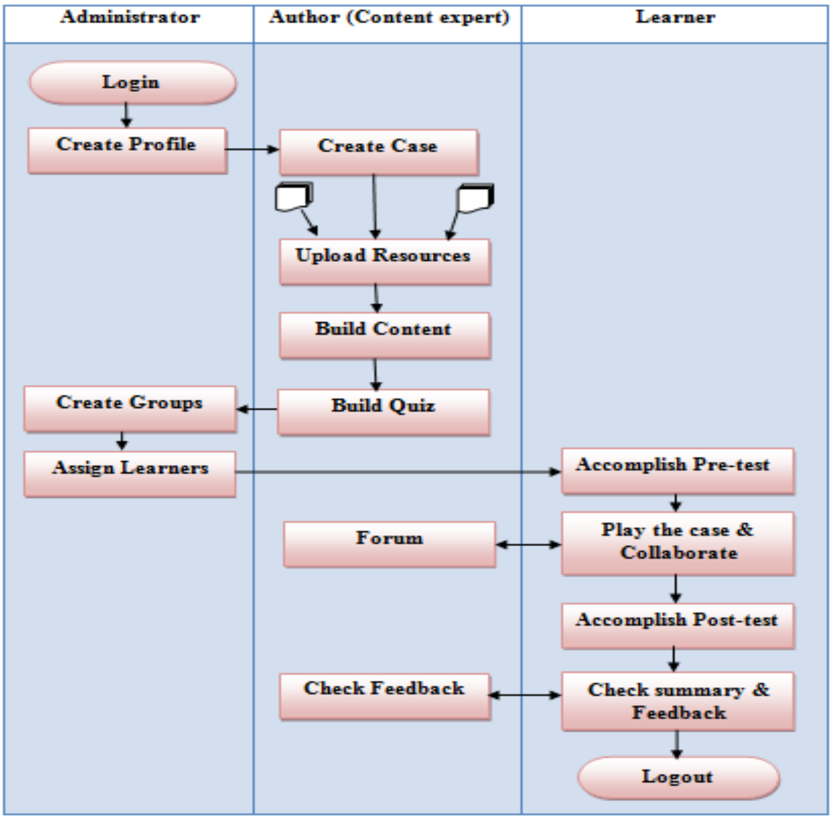

Fig. 7. Mobile Clinical Cases application workflow

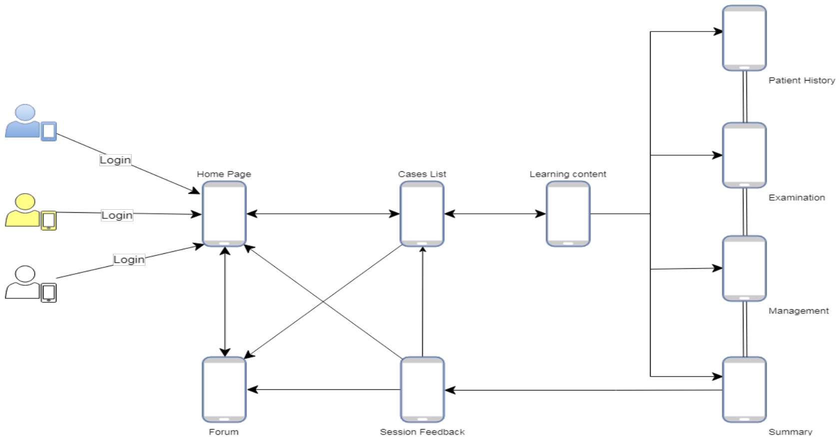

Fig. 8. Navigation diagram

7 Conclusion

Mobile learning introduces great opportunities for the enhancement of collaborative learning by offering more flexibility and personalization of learning and allowing it to be more student-centred. However, this type of learning is still underestimated or not used effectively into curriculums. The five axes m-learning integration framework aims to propose a thinking guide for mobile devices integration in learning curriculums. This framework can be correlated with other models such as the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) in order to define in details the aspects at stake for optimal integration. The main purpose of this study is to help educators and instructors with poor technology knowledge to consider every aspect involved in mobile learning systems integration. The experimentation is still running while researchers are collecting data to further ameliorate the mobile application. Feedback from researchers and educators on the impact of this new framework would be very valuable in order for authors to evaluate the efficiency of their model in various fields of learning. Further studies will be conducted, to first analyze users behaviour and data of the application, in a second time the limitations and the amelioration of the framework if there is anything omitted before.

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