Intelligent Mobile Cloud Education

Smart anytime-anywhere learning for the next generation campus environment

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Abstract — **Learning has evolved significantly, creating several challenges for the traditional educational system. This paradigm shift in education is imminent and has since gathered a great deal of interest in recent years, as an attempt to bridge the technological gap in the educational sector. Under EBTIC's international iCampus (intelligent campus) initiative [1], this paper examines mobile cloud-education – a novel cutting-edge research in the area of intelligent learning, based on the design, development and testing of a mobile cloud learning system. This system can provide smart anytime-anywhere learning that is customised and adapted to individuals, and delivered via personal portables devices. A preliminary testing of the system reveals its effectiveness in supporting teaching and learning in an intelligent campus environment.**

Keywords- mobile cloud education; cloud learning; mlearning; intelligent campus (iCampus)

I. INTRODUCTION

Cloud education or learning is a new and emerging concept associated with cloud computing [2], [3]. Cloud learning is built on three services models (Infrastructure as a Service - IaaS, Platform as a Service - PaaS, and Software as a Service - SaaS) but also has various definitions. Here we define cloud learning as a shared pool of learning courses, digital assets and resources, which instructors and learners can access via computers, laptops, IP-TVs, mobiles and other portable devices. The "cloud" associated with learning is therefore similar to public utilities, in which consumers can plug into and use anytime and anywhere. Learners can collaborate anywhere in the "Cloud": study, experiment, explore, complete tasks, and provide assistance to others. Learners in the "Cloud" can also select suitable resources and record individual learning outcomes and processes. The characteristics of cloud learning are as follows:

1) Storage and Sharing: Learning outcomes and resources can be stored in the "Cloud", which allows an almost unlimited storage capacity. Documents can be commonly edited and shared in the "Cloud" through services such as GoogleDocs, Live Skydrive, and the Office Live.
2) Universal Accessibility: Learners can study as long as they have access to the network, online, mobile, TV or satellite. Cloud learning also makes low-cost terminal access possible, because software, applications, and data are all run on cloud servers. This improved accessibility can greatly benefit developing regions.
3) Collaborative Interactions: Learners can cooperate anywhere in the "Cloud". From social learning perspectives, they can collaboratively build common knowledge through these frequent and convenient interactions.
4) Learner Centered: Cloud learning is heavily people-oriented, which meets the individual needs of learners. Learners in the "Cloud" select suitable resources and can keep track of their learning progresses and outcomes.

Mobile cloud education – a novel unification of cloud and mobile learning – is a relatively new concept that holds great promises for the future development of education. The two learning modalities can naturally merge, because the characteristics of cloud learning overlaps with mobile learning [4]. The definition of mobile learning has also been evolving, from the early definition of "learning with mobile devices" to the current one that emphasizes "learner mobility resulting from the use of mobile devices". In both definitions, users can acquire learning content from the centralized shared resources and engage in anytime-anywhere context-aware learning via portable devices. The shift in defining m-learning from mobile devices to mobile learners requires designers not to design instruction for a new class of mobile technologies. Rather, they need to broaden their perspective of what the mobility of the learner entails in relation to learning. By recognizing this focus shift in design, it is possible to identify a dichotomy of guidelines with one set focusing on the technology and one set focusing on the learner. In addition, researching mobile learning from mobile learner's perspective requires the study of "…how the mobility of learners augmented by personal and public technology can contribute to the process of gaining new knowledge, skills, and experience" [5]. This multidimensional view of mobility greatly enriches the discourse in mobile learning and also poses new directions for research and development, especially when in synergetic amalgamation with cloud learning [6]-[8]. This hence forms the main focus of this paper which will address and evaluate some of these issues.

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II. A CLOUD-BASED INTELLIGENT LEARNING MODEL

The main goal of an intelligent learning system is to provide learners with a personalized learning environment by considering the learners' learning objectives, cognitive abilities, and knowledge level. Key components of intelligent learning include learning diagnosis, dynamic organization of learning content, and automatic selection of learning strategies. However, existent learning systems are often too rigid to accommodate learners' cognitive characteristics and needs [9].

Although many types of intelligent learning systems are available, five key basic modules are common in most systems, namely, the student module, the expert module, the pedagogical module, the domain knowledge module, and the communication module. Most intelligent learning systems incorporate course sequencing techniques, and the pedagogical module is responsible for setting the principles of content selection and instructional planning [10]. A commonality among these learning systems is to support on-demand learning, to provide personalized learning support, and to compile and share resources among multi-platforms. However, none of the systems have been implemented on a large scale. Building cloud-based intelligent learning systems is hence an imminent paradigm, because these systems can support resource sharing among different platforms, and deepen the support of personalized learning services to meet different learners' needs.

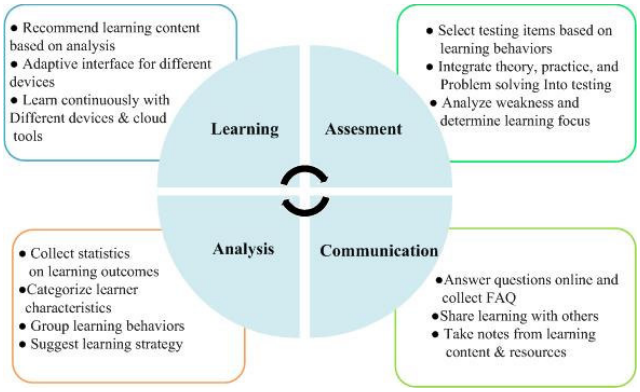


Figure 1. The "recursive" intelligent learning model.

Based on the above, a theoretical model framework for cloud-based intelligent learning is hence outlined as shown in Figure 1. This framework can be used to guide the design and development of an intelligent mobile cloud education system, which can situate learners in an intelligent learning environment. The nature of this model is recursive in four cycles: Learning, Assessment, Communication, and Analysis, which reflects the intelligent, sustainable and recursive nature of the digital learning process. The uniqueness of this "Recursive" Intelligent Learning Model includes:

- Support of individualized learning
- Provision of context-aware learning
- Integrated learning resources and management
- Capturing learning activities for analysis and in-depth research
- Support of continuous learning with a variety of tools and devices.
- Enablement of multi-platform access to learning content and resources

A. *Learning stage*

In the past decades, learning has evolved from traditional classroom learning to eLearning, to mLearning (mobile learning) and recently uLearning (ubiquitous learning). The role of teaching and learning has also changed, from a teacher-centered approach to community-centered approach, and from information transfer to knowledge creation. With the evolution of learning theories and frameworks, intelligent learning systems are hence needed to support different ways of learning and continuous learning. The intelligent learning model, as shown in Figure 1, is based on smart cloud computing. Learning systems built upon this model can support cloud learning from the following aspects:

1) Intelligently providing learning resources for learners by recommending the appropriate learning content to users based on automated analysis of the learners' behaviors and their learning outcomes.

2) Learning content is adaptively displayed on different learning devices, known as "multi-screen in one". Users can connect to the learning system from any devices and learn without much interface interruption.

3) Support for continuous learning. In connection with the aforementioned "multi-screen in one", learning content is customized for the multi-tenancy feature in cloud computing. The knowledge service system in the intelligent learning system can transform network-centered learning service to customized intelligent learning service, which provides users with open, intelligent, active, accurate, convenient, ubiquitous and low-cost intelligent learning services.

B. *Assessment stage*

Assessment is an important component in learning, and it can help to ensure the alignment of learning objectives and outcomes. In traditional classroom learning, evaluation is often done by testing only. eLearning often uses a variety of evaluation methods, such as observing learners' interactions and activities online, evaluating learners' products, and analyzing the Q-As. However, the assessment methods used in eLearning lacks in-depth analysis and cannot give timely feedback to learners. Evaluation conducted in the intelligent learning system improves upon the shortage of the traditional eLearning, from the following three aspects:

1) Recommendation assessment is based on learning behaviors and progress.

2) Tests can be created from theory, practice, and learner interests, and provide timely detection of problems and weaknesses emerging during the process of learning. Other assessment methods (report-writing, artifact-production,

etc) will be used to help learners consolidate their learning outcomes.

3) Based on the assessment results, it is possible to detect learning weaknesses and intelligently select learning content for users.

In summary, intelligent assessment can periodically evaluate learning activities and outcomes, so as to provide personalized learning services as described in the cloud model.

C. *Communication or Interaction stage*

In learning, communication and interactions play an important role and they are crucial to the success of online learning. The well-known transactional distance theory [11], categorizes interactions in distance learning into three types: interaction between learners and learning content, interaction between learners and teachers, and interaction among learners. In online and mobile learning, learners can be isolated and dispersed. They need peer collaboration and frequent instructor guidance to stay on track. Interaction and cooperation can not only help the exchange of knowledge but also enables learners to participate more actively in the learning process, leading to increased motivation and knowledge-building [12]. However, without instructor validation, the accuracy of knowledge constructed among learners can be questionable. Cloud-based intelligent learning system can provide tools to support frequent and timely communication among teachers and students, so as to improve the quality of knowledge construction. This is accomplished through the following three functions:

1) Provides ways for learners to share their learning, from strategies to content.

2) Collection of FAQs and prompting instructors to address them. Questions and the answers will be stored in a searchable database, which learners can easily access.

3) Provision of tools for online note-taking and storage of notes in a searchable database. Thus, the notes become sharable and retrievable, conforming to the cloud nature of learning.

D. *Analysis stage*

In a traditional or virtual classroom with large numbers of students, it is often impossible for teachers to analyze each learner's performance and make recommendations to them of appropriate learning methods and materials. The non-cloud-based eLearning can provide basic statistics of teaching and learning, but still lacks the power of a cloud-based analysis function. Cloud-based intelligent learning system adopts the cloud-based multi-tenancy concept together with data mining to generate comprehensive analysis of learning data, including:

1) Analysis of learner characteristics and provision of individualized learning support.

2) Statistical analysis of learning outcomes. Based on this analysis, the system will recommend the appropriate learning methods and materials.

3) Recommendation of learning methods based on an analysis of learning activities, methods, behaviors, learning styles and other related records.

4) Grouping of learners based on their learning behaviors. The system can group learners based on certain attributes and then recommend appropriate learning content.

III. INTELLIGENT MOBILE CLOUD EDUCATION SYSTEM

Figure 2 depicts the architecture of the devised intelligent mobile cloud education system that is built upon the above-mentioned recursive intelligent learning model. The intelligent engine is the central core of the Learning-Assessment-Communication-Analysis (LACA) model. Aligning with databases and indexing principles, the Intelligent Engine builds up a personalized learning plan for the users, and adjusts it from time to time based on learners' feedback and outcomes. The assessment for learners examines both their learning effectiveness and outcomes, rather than time spent on learning. Such a dynamic engine certainly generates more efficient results, but it inevitably requires better knowledge management with finer granularity and vectors.

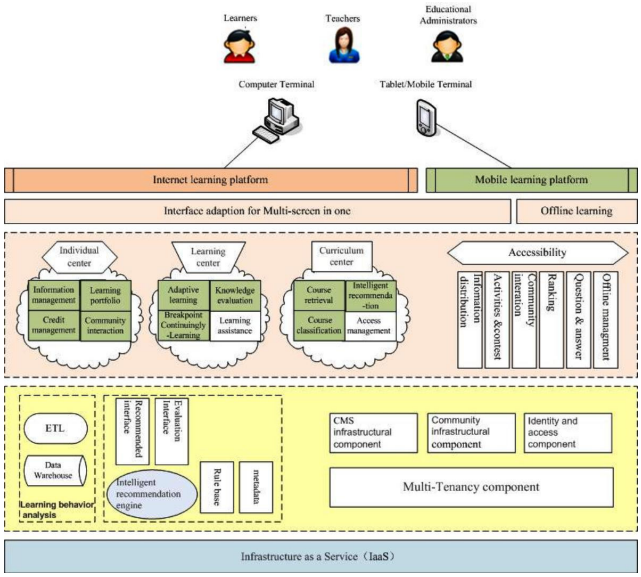


Figure 2. Intelligent mobile cloud education system architecture.

The system architecture is made up of the following components: CMS infrastructure, community infrastructure, identify and access, multi-tenancy, database, testing, and intelligent recommendation. Its core functional elements consist of a learning engine, some Metadata, and a rule base. Through ETL (Extract, Transform, and Load) software tools, the learning engine extracts a learners' study history (stored in a data warehouse) and analyzes the learners' test results and learning behaviors. Based on these data, it intelligently recommends or pushes suitable learning content to each individual learner. Metadata refer to learners' basic information generated during the learning process, such as their current learning content and scores. The rule base refers to the system's rules that manage the learners' interaction with the system. The rules can be altered both by the teacher and autonomously by

the system (as it becomes familiar with the student's abilities and learning behaviors). Based on these data, the system can determine learners' knowledge level with the current subjects, and then present the appropriate learning material to the learner. By accessing these rules, learners can also find out their own learning progress.

In mobile cloud learning (MCL), learners can communicate with teachers and other learners about their study, questions or problems. When teachers answer these questions, the intelligent learning system can automatically match the questions with corresponding answers and then save them in a database. Next time, when the same questions are asked, the system will match the questions with answers and present the answers to the users. The intelligent learning system can also extract typical questions or problems through ETL and collect learners' study notes, and then save all these important resources in the database. ETL is a process in database usage and especially in data warehousing that involves: (1) extracting data from outside sources, (2) transforming it to fit operational needs (which can include quality levels), and (3) loading it into the end target (database or data warehouse). The database will process and analyze these collective resources and provide value-added feedback to learners. Through all these functions, learning is no longer an isolated activity. Learners can interact more frequently with others, which will greatly improve their interests and expand their knowledge.

Apart from that, the intelligent learning system provides an individual center, learning center, and curriculum center to support various ways of learning, such as multi-screen-in-one (i.e., continuous learning without interruption), interface adaption, and intelligent recommendation based on students' learning record. The learners can have one or more terminals/ learning devices (PC, mobile phone, tablet computer) in an intelligent learning system. When learners use their individual learning device, the system will remember where they are in the learning process and will help them to immediately resume their previously-ended learning session. In addition, it can also recommend to learners relevant content, based on their current record of learning. In summary,

- The system can provide learning material on-demand, including video from a live class or a recorded session.
- The system can synchronize learning records to the "learning cloud".
- Learners can access the "learning cloud" anytime anywhere on various mobile devices and can resume learning from where they stopped the last time. This feature is also known as "continuous learning without interruption".

In short, the platform of the system is comprised of the following centers and management functions:

A. *Individual center*

The individual center has four modules: information management, learning portfolio, credits management, and community interaction. The information management module includes user registration and log-in as well as personal information management. The learning portfolio module includes the access, save and synchronization of the learning portfolio. The credits management module includes personal credits account management, learning records, and the add-up of credits as well as the exchange credits to certificates. And the community interaction module includes BBS, sharing, and uploading contents.

B. *Learning center*

The learning center consists of four modules: adaptive learning, test, course learning, and continuous learning. Adaptive learning refers to the learning perception management and the learning model management. The test module includes test choice, problem sets, scores, and the add-up of the learning results. The course learning module includes curriculum syllabus, course display, work schedule, and homework. The continuous learning module contains course bookmarks and course preload management.

C. *Curriculum center*

The curriculum center has three modules: course retrieval, course classification, and intelligent recommendation. Course retrieval module includes course inquiry and keyword search, course ranking, and reading collection. Course classification module can classify from more than one dimension such as category, stage, source, crowd, evaluation, content provider and keywords. In addition, it can also display courses. Intelligent recommendation module will push a list of recommendations to users according to their preferences, places visited in the learning system, and their learning records. It can also send direct messages to the users.

D. *Display and access management*

This subsystem contains terminal identification, layout management, subscription-and-push, and authority management. Terminal identification module refers to the intelligent adaptive content output function based on the identification of the different mobile browsers and screen resolutions. In layout management, the administrator manages and maintains the content of the page. In the subscription-and-push module, users can subscribe to all kinds of learning information, and the administrator can push real-time information and recommend courses or learning materials to the user. Finally, the authority management module includes user management, role management (students, teachers or administrators), and assign different roles to users: visitors (not registered users), ordinary users (register online), real name users, and course users.

IV. SYSTEM TESTING RESULTS AND ANALYSIS

The mobile cloud education system was initially tested with a set of targeted users mainly to assess its usability and instructional effectiveness. The users can start by downloading the mobile learning client applications or directly accessing the mobile learning portal. The core learning services are based on the HTML5 cloud application architecture. Android mobile phones and IOS iPad are the portable devices used in the testing evaluation. The former is based on the Android Mobile Phone Platform (Model: Samsung Galaxy Ace S5830; CPU: Qualcomm MSM7227 800MHz; Operating system: Android

OS 2.2; Memory: 150MB), and the latter is based on the IOS iPad (Model: IPAD 2; CPU: A5 Intel-duo 1GHz; Operating system: IOS 4.3; Memory: 512MB). The evaluation of the system is based on the ASTD's (American Society for Training & Development) E-learning courseware certification (ECC) standard [13] and the specifications for evaluating web-based courses CELET-22 [14] published by the informatization standards committee of China's Ministry of Education [15].

The ASTD ECC standard consists of three parts – usability, instructional design, and technology, amounting to about 32 items. Usability includes navigation, orientation, feedback tips, work links, tag links, help information, readability, text production quality, etc. Technology includes technical requirements, media installation, media removal, reliability, responsiveness, media derived, etc. Instructional design has the most criteria, such as informing objectives, getting attention, maintaining interest, keeping motivation, guiding learning, presenting content, providing practice, promoting learning transfer, providing comprehensive training, providing feedback and learning assistance, evaluating learning, avoiding cognitive overload, etc. China's CELTS-22 standard consists of 36 items, which evaluate the quality of online courses from four aspects: 1) content & organizational structure, 2) instructional design (objectives, teaching methods, & evaluation methods), 3) interface design (style consistency, screen layout, navigation, content retrieval, operational assistance), and 4) technology (system stability, compatibility, function of multimedia, etc.)

The evaluation matrix that was developed (see Appendix I) synthesizes the evaluation indexes from ASTD and CELTS-22, and has four major categories: Instructional Design, Interface Design, Interaction Design, and Technical Design. Each of the four has a few sub-categories. In addition, new items are created to support mobile and cloud learning. Obligatory nature means whether the evaluation criterion is a Must-have or an Optional one. There were a total of five evaluators (learners), using either Android phones or iPad, to access one course -"the fantastic fountain". Each learner studied for about 15 minutes, using the following procedure:

- Log in from: http://m.shlll.net, click the green button on the left.
- Click "Linguistic Literacy" from the Course List
- Click "The fantastic fountain"— *First one on the list*
- Enter the course main page, play the video and access other course material.
- Click on the course Menu, and go through each chapter, take the quizzes, provide course comments, and answer a few survey questions.
- Once the study is completed, click "completed", then store this course in one's Individual Center.

During each step, each evaluator (learner) scored the system on a scale of 0 (worst) to 5 (best), using the evaluation matrix as specified in Appendix I. The results for the four categories are as shown in the following tables (note: decimals are rounded to the nearest point).

Figure 3. Mobile cloud education evaluation procedure.

A. *Instructional Design*

From the evaluation results, the overall instructional design of the course is satisfactory.

a) Navigation: this seemed to be clear; and there were clear indications when users move to different chapters, pages, and other knowledge points (i.e., learning objects). Users were able to visit all modules of this course without any assistance.

TABLE I. SCORES FOR INSTRUCTIONAL DESIGN

Category	Obligatory nature	Sub-category	Average score
Navigation	M		3
Progress marker	O		4
Information retrieval	M	Retrieval function	2
		Retrieval results	2
Support for personalized learning	O	Control of personalized learning	3
Learning engagement	O		3
Learning support	M		1
Learning assessment	M	Customized assessment	2
		Quality of the assessment	3
		Feedback from the assessment	4
Feedback to learner	M		3
Total score	**A total of 30 out of 55 (and 20 out of 40 for the "Must" elements)**		

b) Progress marker: 60% of the evaluator gave this one 3, and 40% gave it a 4. When the users exit the system, their learning path and records will be stored in the "Cloud". And they can resume easily when logging into the system the next time. All users rated this function as critical for their continuous learning.

c) Feedback to learners: users were satisfied with the feedback received at different stages.

B. Interface Design

The system interface received high scores from all users. Aesthetically, 80% of the users thought the interface design was consistent, with excellent use of color and contrast (white and green). Language use aligned with Chinese and English standards. Pictures were appropriately inserted to illuminate the content.

From an eligibility perspective, fonts used in the courseware were found to be of the right size. In addition, video resolution was reported as being high, with clear narration and engaging soundtrack.

From the usability perspective, the interface was found easy to navigate. Its design conformed to educational psychology guidelines, and evaluators were able to use all the features of the course without human or automatic assistance.

TABLE II. SCORES FOR INTERFACE DESIGN

Category	Obligatory nature	Sub-category	Average score
Interface design	M	Style consistency	4
		Language consistency	4
User-friendliness	M	Quality of pictures	4
		Eligibility/visibility	4
		Operational efficiency	4
Layout	M		4
Markers of important words and buttons	O		3
Total Score	**A total of 27 out of 35 (and 24 out of 30 for the "must" elements)**		

C. Interaction Design

Evaluators also liked all the interaction features, including taking the test and getting immediate feedback, selecting what to study, system recording of their learning path and progress, and the technical and study reminders. In addition, they reported liking the touch-screen function more than keyboarding. Touch-screen makes the interaction more direct and effective, which seems to increase the learners' sense of interaction with the system.

In addition, the learner-learner interaction feature received high ratings. The Questioning-answering module provides opportunities for learners and instructors to exchange knowledge and resources.

TABLE III. SCORES FOR INTERACTION DESIGN

Category	Obligatory nature	Sub-category	Average score
Learners-system & devices	M		4
Among learners	O		3
Total	**A total of 7 out of 10 (and 4 out of 5 for the "must" elements)**		

D. Technical Design

Technical operation was also smooth. All buttons and links worked as designed. The system did not malfunction or freeze during the testing. Touch-screen functions were also free of bugs: selecting, moving, resizing etc. all worked.

The servers responded quickly with the wait time for all operations being less than 1 second. Multimedia elements also loaded and displayed within a reasonable time. Video and audio played smoothly on all wireless bandwidths.

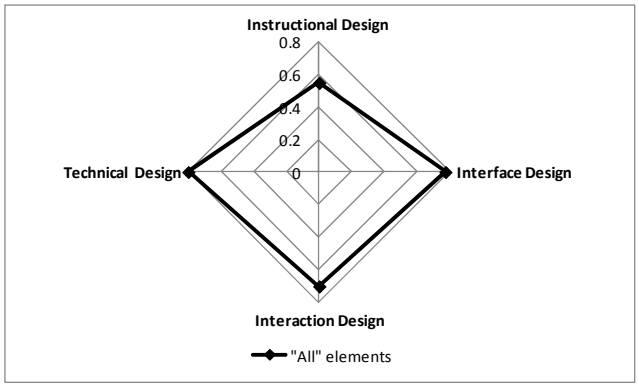
Users rated the intelligent saving function highly. During power outage or switching of devices, the system was able to remember the learners' progress. When users returned to the system, they were able to resume from where they stopped the last time. The system successfully supported continuous learning through user interface control (i.e. users can use any devices to access the learning system and content). This is one of the innovative features of the system and also reflects the characteristics of cloud computing and learning.

TABLE IV. SCORES FOR TECHNICAL DESIGN

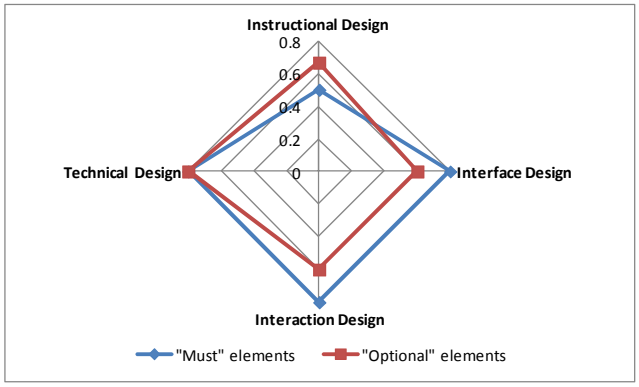
Category	Obligatory nature	Sub-category	Average score
System stability	M	Enter and exit	4
		Buttons and links	4
		Flow of operation	4
Speed of server response	M	Multimedia	4
		Response to operation	4
Intelligent saving of learning records	O		4
Independence	O		4
Total	**A total of 28 out of 35 (and 20 out of 25 for the "Must" elements)**		

E. *Overall evaluation summary*

Overall, the total score for the devised mobile cloud education system is about 92 out of 135 based on all the listed evaluation criteria. In other words, its percentage rating is about 68.2%. This is composed of a subset of about 68 out of 100 for the "Must" criteria (i.e. ≈ 68.0%) and a subset of about 24 out of 35 for the "Optional" criteria (i.e. ≈ 68.6%). A summary of the system evaluation score is pictorially illustrated as shown below. As seen from the figures, the system's "Instructional Design" (especially its "Learning support" category) has room for further enhancement and improvement, as compared to the other three design counterparts.



(a)



(b)

Figure 4. Overall mobile cloud education evaluation results.

V. CONCLUSIONS

This paper has put forward the concept of mobile cloud education based on an amalgamation of cloud-learning and mobile-learning. The prime objective of mobile cloud education is to provide smart anytime-anywhere learning for the next generation intelligent campus (iCampus) environment. An innovative intelligent mobile cloud education system was then built and tested, that is based on the proposed recursive intelligent learning model. The system was tested using a mix of Android phone and iPad platforms. Regular functions on both devices (making calls, taking notes etc.) were not interrupted during the testing. Overall, the initial testing of the intelligent mobile cloud education system has been satisfactory. However, more testing is needed with all other commonly used mobile devices (such as iPhone, Tablet PC, desktop, mini-laptop) and on a larger scale (both in terms of learners and learning content). More work would also be carried out to further refine and develop the system, especially in the "Instructional Design" aspect. Extensive data collection would also be conducted to further demonstrate the effectiveness of this system in supporting teaching and learning in the educational environment.

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Appendix I: System Evaluation Matrix

Evaluation Categories	Evaluation Sub-categories	Obligatory nature	Index Description (best-case)
Instructional design	Navigation	M (Must)	The markers between pages and content are clear. Learners can identify their locations throughout the course and easily access each module.
	Progress marker	M	When returning to the system, learners will be reminded of the content they were accessing during the last log-in.
	Data/information Retrieval	M	Supports keywords retrieval in multimedia format. Detailed content can be accessed from the search results.
	Support for personalized learning	M	Learners can customize their learning process and environment, such as content, learning path, learning progress, testing methods, frequency, types of feedback and learning settings (font size, background color, style, theme, etc.).
	Note-taking tools	O (Optional)	Provides tools to record notes that can be accessed anytime
	Learner Engagement	O	Use the necessary means (games, story, music, etc.) to stimulate and maintain learner interest. The same media are consistent in design. Engagement is assessed by: the length of time learner spent on the courseware, frequencies of courseware visit, that learners visit the courseware, participation in activities, and completion of exercises.
	Learning support	M	Learners can get adaptive learning assistance and guidance in the whole learning processes, including FAQs, courseware usage, tips for learning, and access to experts' answers.
	Learning assessment	M	Provide more than 1 type of test method (single selection, multi choice, true or false, etc.). Avoid questions that require the entering of large amount of texts. System scores learner and provides detailed comments.
	Feedback to learners	M	Provides timely and effective feedback after testing, exercise and learning, similar to the feedback system in level-based games. . Learners will be motivated to continue their study.
Interface design	Style consistency	M	The appearance of each element matches with main style, page layouts are consistent, the same structure, media use consistent design.
	User-friendliness	M	Supports automatic switch to full-screen display. Uses appropriate text size, appropriate resolution of picture and video. Uses appropriate contrast in design.
	Layout	M	Each page element varies in size and location, to show its importance. Reasonable layout with key points highlighted and easy viewing.
	Markers of important words or buttons	O	Provides a clearly identifiable marker for special buttons; provides links for important texts.
Interaction design	Interaction between learners and the mobile terminals/devices	M	Learning devices with non-touchable screen: uses key shortcuts (left soft as enter, right soft as exit), use page number keys to turn the pages. With touchable screen: support multi-touch, and drag-drop. Supports various interactive modes such as jigsaw, touch flop, and interactions (Q-A, feedback, modeling, simulations, etc.)
	Interaction among learners	O	Learners can find other learners by updating their friends' list and use message and e-mails to communicate. Online platforms support learners' communication and collaboration.
Technical Design	System stability	M	System is free of bugs when operating in normal situations. No interruption or crash while being in use. Buttons on touch-screen can select items, drag, and zoom in.
	Speed of Server Response	M	Multimedia elements open fast, load and run smoothly. System responds fast to user request, with minimum wait time.
	Battery life	M	Learning system takes moderate power, to support mobile learning.
	Intelligent saving of learning records	O	Mobile courseware can save the learning process intelligently during power outage or system outage, so as to support continuous learning.
	Functional Independence	O	Mobile courseware and the mobile device's other function are separated. And mobile courseware does not affect the use of other functions on the devices.
	Security of Networking and downloading	O	Automatically checks the security of networking when learners access the internet. Gives warning when there is any risk.