Design and Development of a Platform for a Ubiquitous Calculus Teaching Assistant

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Abstract—This study developed a mobile learning system for smartphones and mobile devices to enhance calculus learning. A ubiquitous calculus teaching assistant (UCTA) app was developed for iOS and Android operating systems. App content was based on freshmen prerequisite calculus courses and managed using a Java-based server. The apps underwent testing by calculus students who were able to use the apps immediately after installation. The app enabled students to take pictures of their written work and upload the images to the server, thereby overcoming the need to input special mathematical symbols through conventional smartphone input methods. The server immediately notified instructors of student inquiries through the UCTA apps installed on their mobile devices, facilitating an immediate response or sharing of relevant information with the entire class. Using the UCTA app, the students were able to ask follow-up questions in response to the instructors’ feedback, thus achieving interactive and cooperative learning. Moreover, the app provides a function for sharing extracurricular materials or course-related questions with the class. Finally, a similar version of the UCTA program was designed for Windows operating systems to provide system access for students who do not own a smartphone.

Index Terms—ubiquitous, calculus, ubiquitous teaching assistant

I. INTRODUCTION

During the Web 1.0 stage of the World Wide Web, most computer users were restricted to receiving knowledge. Since the emergence of Web 2.0 technologies, computer users have not only been able to express their opinions online as well as publish and share personal information, but they have also been able to communicate with others through interactive platforms [1]. Subsequent developments in information technology led to the emergence of wireless network, followed by the proliferation of iOS and Android smartphones and tablet devices, extending interpersonal communications beyond spatiotemporal constraints; consequently, people are no longer limited by conventional learning environments. The evolution from early online learning, to wireless mobile learning, to the currently mature ubiquitous computing technologies has overcome the physical limitations of education, resulting in the emergence of ubiquitous mobile learning environments. Ubiquitous mobile learning marks a new pedagogical milestone. By integrating digital learning, wireless Internet, and mobile technologies, ubiquitous learning enables learners to spontaneously retrieve learning materials and to interact and communicate with teachers and peers via mobile devices at any time and location.

Ubiquitous mobile learning eliminates the operational barriers of hardware systems that people typically associate with using the Internet. The absence of network cables, immediate connectivity through any terminal device, and the convenience of diverse digital content services and learning materials provide an open network environment for sharing information. This environment not only makes life and work more efficient, but also realizes the concept of a virtual ubiquitous information network society [2],[3].

Ubiquitous mobile learning directly influences cultural and educational institutions. The availability of wireless broadband, third-generation mobile Internet, and relevant mobile devices (i.e., smartphones and tablet computers) combine to form a diverse mobile learning environment. Recently, numerous researchers worldwide have used satellite positioning, Bluetooth networks, third-generation mobile Internet, Wi-Fi Internet, Radio-Frequency Identification (RFID), and Google Map technologies to develop network-learning systems that can track the location of learners and actively provide information that is suitable for their ability overcoming barriers to ubiquitous learning [4], [5]. Several researchers have emphasized the importance of sharing knowledge and personal experiences, participating in cooperative learning and interactive activities through ubiquitous mobile learning applications, and providing correct and useful information to maximize the effectiveness of ubiquitous mobile learning environments [6]-[8]. In addition, costly mobile devices are a critical barrier to promoting ubiquitous mobile learning environments. Affordable mobile devices promote the diffusion of ubiquitous mobile learning environments [9]. However, smartphones are not only prevalent but also becoming increasingly affordable. This has lowered the barrier to ubiquitous mobile learning environments considerably. Therefore, research on ubiquitous mobile learning should be encouraged presently.

Chu et al. incorporated Personal Digital Assistant (PDA) and RFID technologies in the teaching methods of a Grade 5 science curriculum and noted a positive
influence on student learning attitudes, performance, and efficiency [10]. Additionally, Hsiev et al. used PDA and RFID technologies in similar applications and demonstrated their effectiveness as instructional and learning modes with evidence of marked improvements in student learning response [11]. Furthermore, ubiquitous instructional environments are also crucial in designing instructional materials and methods. Liu and Chu applied PDA and RFID technologies to English listening and speaking curricula in which game-based and non-game-based modes yielded statistically significant differences in learning effectiveness and learning motivation; in particular, the game-based mode was considerably more effective [12].

Following digital learning, the ubiquitous mobile learning method has revolutionized learning. Learning environments have transcended conventional classroom settings to become ubiquitous learning environments, with instructional content evolving from conventional textbooks to include any searchable knowledge and content on the Internet. Diverse ubiquitous mobile learning modes are typically the result of technological progress and instructional innovation. Mobile learning apps naturally emerged following the introduction of wireless Internet technologies and compact mobile devices, such as smartphones and tablet computers. Without the restriction of network cables, learners can download learning materials onto wireless devices and learn in any location, thereby extending the physical boundary of classroom education to outdoor learning. Consequently, developing personalized, learner-centered, context-specific, cooperative, up-scalable, and accessible next-generation learning environments in line with the frameworks of current learning theories poses a difficult challenge for all education professionals and information technology developers involved in the current learning revolution.

II. METHOD

A. Conditions of a Ubiquitous Mobile Learning Environment

Researchers have recommended providing necessary infrastructure when developing ubiquitous mobile learning environments; this involves developing systems that support broadband and wireless connectivity, mobile device or smartphone compatibility, mobile computing and processing functions, open architectures, and standardized communication protocols [2], [3]. Such requirements are facilitated by most schools providing wireless Internet connections and the increasing prevalence of smartphones. Currently, iOS and Android operating systems are also the most widely adopted systems on the smartphone market, communication protocols are becoming standardized, the cost of smartphones is becoming more affordable, and the majority of such devices feature installable apps, cameras, and wireless connectivity. Therefore, these conditions excluded the limitations in mobile learning environments possibly encountered during this study.

B. Properties Exhibited by a Ubiquitous Mobile Learning System

Chen et al. also indicated that ubiquitous mobile learning is characterized by six features: urgency of learning need, initiative of knowledge acquisition, mobility of learning setting, interactivity of learning process, situating of instructional activity, and integration of instructional content [13]. Curtis et al. indicated that from a practical perspective, ubiquitous learning must be established on the basis of permanency, accessibility, immediacy, interactivity, and situating of instructional activities [14].

The aforementioned studies show that ubiquitous mobile learning systems must enable students to proactively acquire knowledge, facilitate convenience, and provide immediate access to knowledge resources. Furthermore, such systems must allow for interactive and mobile learning processes. The ubiquitous calculus teaching assistant (UCTA) app proposed in the present study features the aforementioned characteristics. After calculus classes, students can immediately take photos of their work and upload them to the server as soon as they encounter problems, at which point the instructors are immediately informed so that they can promptly provide a solution. This process enables students to be proactive in their learning by providing a convenient interface for immediate knowledge acquisition. Through using the system, instructors can share their responses with individual students or the entire class, and all students can participate in discussing the problems encountered by other students; thus, the proposed system provides interactive mobile learning functions. Extracurricular materials or course-related problems encountered outside of regular classes can also be shared with the entire class through the proposed UCTA system, thus providing ubiquitous assistance functions to teaching.

C. System Analysis

The proposed system primarily provides support for students learning calculus in addition to their regular classes. In using the system, students can take pictures of the problems they have difficulty solving by using their smartphone camera and then upload them to the server. Instructors are immediately notified through the iOS and Android push notification modules, and they can immediately respond to students’ questions or share the problem with the entire class. Students can then respond to their instructors’ responses; thus, the system provides an interactive and cooperative learning experience. Furthermore, extracurricular material and course-related problems can also be disseminated to the entire class. Finally, a Java-based version of the UCTA app was designed for use on a personal computer by students who do not own a smartphone. The functions on the PC version of the app are identical to those on the smartphone version. The system functions were developed according to the following procedure.

Step 1: Students write the calculus problems on a piece of paper, take pictures of them with their smartphones camera, and upload the images to the server. Students
who do not own a smartphone can use the PC version of program (executable on the Windows operating system).

Step 2: The server immediately sends a notification of the students’ problems to the instructors’ mobile device. The instructors can search through the students’ inquiries and respond accordingly.

Step 3: Similar to Step 1, the instructors can take a picture of the written solutions, upload them to the server, and select whether to share the response with the entire class or any individual student. Additionally, the instructors can disseminate supplementary material by uploading images to the server and sharing them with the entire class.

Step 4: After receiving a response from the instructors, the server immediately notifies the students of the response uploaded. The students can then immediately search for the response or view supplementary material online.

A search function was also incorporated into the app to provide a means for searching through the problems raised by the students as well as the corresponding responses from the instructors. Students can discuss the instructors’ responses and contribute ideas or ask questions accordingly, achieving interactive and cooperative learning. Finally, the system provides a feedback function for students to report problems related to system operation, response times, and network transfers for the system developers to review and improve the app. The application of this program in other course areas is highly anticipated.

III. RESULTS

A. Student-Version Smartphone App System

Fig. 1(a) is an image of the system login screen, which is displayed when students start the app, and Fig. 1(b) shows the main menu prompted after students login to the system by entering their accounts and passwords.

Fig. 2 shows an image of the problem inquiry page, which can be accessed by selecting the “problem inquiry” function. Students first select a chapter of interest, locate the problem they need assistance with, and then provide a simple description of the difficulty they are experiencing.

Students can check whether instructors have replied by selecting the “check reply” function after submitting the problems. Fig. 3(a) shows an image of the displayed screen when no response has been posted, and Fig. 3(b) shows when the problem that has received a response. Pressing the view button opens the response posted by the instructor (Fig. 4).

B. Instant Notification System

The push notification messaging system provides the instructors with a notification on their mobile device when a student submits an inquiry about a problem; similarly, the students receive a notification on their mobile devices when their instructors respond to a problem. To develop and provide this service, iOS and Android push notification messaging modules were
integrated into the Java system. Figs. 5 respectively show the interfaces for the instructors and students when a notification has been received.

IV. CONCLUSION

The proposed UCTA app is an effective mobile learning platform for providing guidance and discussion. The app was tested on a class of students studying calculus in 2014. Most students who used the UCTA app provided positive feedback. However, an empirical instruction-based case study is necessary to assess the learning outcomes, which will be conducted and verified in follow-up studies.

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REFERENCES


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