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An adaptive personalized learning system

Aekavute Sujarae*[1)], Natchaya Kijmongkolchai[1)] and Chutiporn Anutariya[2)]

[1)]Shinawatra University, 99 Moo 10, Bangtoey, Samkhok, PathumThani 12160, Thailand
[2)]Mahidol University, 999 Phuttamonthon 4 Road, Salaya, Nakhon Pathom 73170, Thailand

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Abstract

Classroom assessment enables instructors to determine learners' needs, adjust instruction, and provide feedbacks to learners on their learning progress. To be truly effective, assessment should be blended as a part of the teaching sequence in order to verify learners' perception of the exposed context. However, this could be time-consuming and resulting in delay and discontinuity of class lectures; thus, making the practice difficult to carry out, especially for a large class size. This paper presents an adaptive personalized learning system that integrates learning technologies with classroom teaching in order to enable a dynamic response learning environment. With an easy-to-use interface, the system supports instructors in continuous assessment of learner's learning progress and automatic selection of supplementary learning materials to suit individual learners based on their performance in a "feedback loop" fashion. In addition, learners' comments and questions are collected and classified into relevant topic categories using Support Vector Machine (SVM)-based text categorization for further review and lecture improvement.

Keywords: Adaptive personalized learning system, Blended learning, Automatic in-class assessment, Support vector machine (SVM)

1. Introduction

Advancement in information and communication technology (ICT) has enabled the delivery of new learning models and pedagogies that are more flexible, personalized, interactive and learner-centered. Integration of such technology with classroom teaching has led to blended learning models which cover a wide range of activities, ranging from completely face-to-face interactions to completely online interactions. In blended learning environment, a key activity that could support learners in achieving learning objectives is to provide regular and timely feedbacks through classroom assessment. In addition, another interesting activity, which simply asks each learner to write and submit a 'one-minute paper' [1] summarizing the things they have learned and the doubt they have, could be adopted. In particular, the one-minute paper activity can obtain learners' perception, while the classroom assessment focuses on evaluating learners' cognitive learning.

Adaptive learning [2] is an educational method that incorporates both learning feedbacks and learning activities as part of an active learning process. At its core, adaptive learning adjusts the learning contents to the knowledge level of the learners based on learners' performance and interaction with the system. The learning can be generalized into two major approaches: facilitator-driven and assessment-driven. In the facilitator-driven approach, different instructional experiences are adjusted based on learners' level of interaction and engagement with the course content. Such approach is useful in providing a granular-level adjustment of the curriculum to increase learners' engagement and retention. The assessment-driven approach, on the other hand, relies on continuous monitoring, tracking and analysis of learners' study performance and dynamically adjust learning materials to suit their capabilities.

Based on the assessment-driven approach as well as the conceptual framework proposed in [3], this paper presents an in-class adaptive personalized learning system, which enables instructors to quickly identify and respond to learners who need supports. Typical formative assessment such as in-class quizzes and the one-minute paper activity are carried out by the system under an instructor's supervision; thereby, off-loading the associated workloads while retaining instructors as an essential part of the teaching process comparable to a traditional teaching-learning environment. Thus, instructors can readily adopt the system without undergoing a major adaptation in an entirely new teaching paradigm.

The paper is organized as follows: Section 2 reviews related works. Section 3 describes the proposed system architecture and the adaptive personalized learning process. Section 4 describes the implemented system. Section 5 draws conclusions.

*Corresponding author. Tel.: +66 2599 0000
Email address: aekavute@siu.ac.th; a.sujarae@gmail.com
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2. Related works

In early years of mobile learning, Personal Digital Assistants (PDAs) have been the potential handheld devices for instructors and learners to perform various learning activities such as notes taking, calculation, ideas sketching, data collection, and resources access [4, 5, 6, 7]. References [8] and [9] are examples of adaptive mobile learning systems based on context-aware capability, which use both learners' physical context (such as location, situation and application) and learners' profiles as key information to determine proper awareness information (learning contents) through filtering rules.

Research in the adaptive learning area shows that vast majority of systems being developed tends to emphasize on building an independent learning platform of oneself. Such systems, although, have potentially great learning benefits for learner with eager learning minds, they could also potentially left behind those with less enthusiasm and motivation to learn, i.e., those who struggle the most. To assist the latter group of learners, an adaptive learning system should instead be utilized during lecture sessions inside the classroom. To fill this need, this paper develops an adaptive personalized learning system, which extends the conceptual framework presented in [3].

3. The adaptive personalized learning system

The key design concept of the proposed assessment-based, adaptive personalized learning system is to utilize learning technologies that assists both instructors and learners during an in-class learning session. The system should possess the following features: ease of use, automated assessment and report generation. In addition, the system should dynamically adjust the learning contents and exercises that match each individual learner's performance. The next subsections respectively describe the proposed system architecture and its adaptive learning process.

3.1 System architecture

Figure 1 illustrates the system architecture which comprises three layers: Database, Application and Client.

The *Database Layer* consists of *Learning Object Repository* (*LOR*) and *Learner Profile & Performance Repository* (*LPPR*). LOR contains learning contents such as supplementary lecture notes, exercises, quizzes, etc. with three levels of difficulty: *beginner*, *intermediate* and *advanced*. LPPR, on the other hand, is used to store learner profiles & performance records evaluated during in-class assessment.

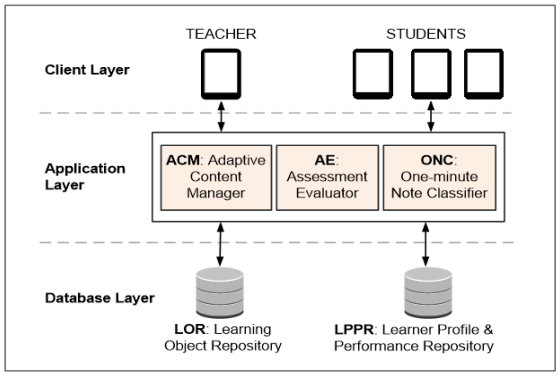

Figure 1 Adaptive personalize learning system

The *Application Layer* contains three essential modules: *Adaptive Content Manager* (*ACM*), *Assessment Evaluator* (*AE*) and *One-minute Note Classifier* (*ONC*). Through in-class assessment, AE determines the learner performance levels on the learned context and maintains the results in LPPR. ACM uses such indicator to determine the appropriate succeeding learning objects for each learner. ONC classifies one-minute notes submitted by learners into proper topic categories for further review by instructors using Support Vector Machine (SVM) classification algorithm. The training dataset comprises of predefined topic categories (labels) and a set of keywords (features) representing each category. Unigram feature extraction is used during this preprocessing phase, since it has shown to yield a highly accurate result for categorizing short sentences [10].

In the *Client Layer*, an instructor uses a mobile learning device to control learning materials presentation sequence and to oversee learner performance, whereas learners use the devices as a visualizing tool for viewing supplementary learning contents, practicing exercises and taking quizzes.

3.2 Adaptive learning process

An assessment-based adaptive learning process, illustrated in Figure 2, can be adopted to adjust the learning experience and provide tailored learning for individual learners, which can hardly be carried out in a typical classroom environment due to time limitation. During a lecture session, the learners' understanding of the exposed context is periodically measured using a series of test questions. The output results are used to determine subsequence supplementary learning materials (such as readings and exercises) for the learners. This feedback loop continues until the end of the class period. Each learner is then asked to submit a one-minute note containing questions or comments on an unclear topic.

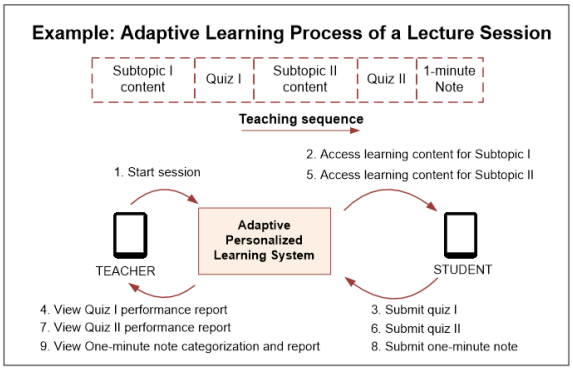

Figure 2 The proposed assessment-based adaptive learning process

4. System implementation and usage

This section discusses how the implemented system works.

Prior to conducting a lecture session, an instructor uses the system to prepare and organize online learning objects (e.g., contents, exercises, and quizzes), which can later be used during the lecture session as part of the instruction and classroom activities. The system allows the instructor to decide when it is appropriate to enable each learning object for learners to access via their learning devices (Figure 3-a). Learning contents and exercises of the appropriate difficulty

Figure 3 Screen shots on instructor's and learner's mobile devices

level that match each learner performance (beginner, intermediate, or advanced) are automatically selected and displayed on the learner's device (Figure 3-b). The system dynamically determines the learner performance level based on the weighted and cumulative quiz scores of each individual learner. At the end of a class, learners are encouraged to complete their one-minute notes online (Figure 3-c).

At all time, the instructor can check the overall class performance including the scores and rankings (Figure 3-d). Learners can also see their own overall performance and rankings with respect to their classmates (Figure 3-e). To review learners' comments and questions and thus improve the current instruction, the instructor can investigate all one-minute notes, which are displayed on the instructor's device (Figure 3-f). Furthermore, such feedback is then automatically classified into proper categories for storage and further review.

5. Conclusions

Key contributions of the proposed and developed Adaptive Personalized Learning System are three-folds: Firstly, it provides an effective learning support tool that can manage and adaptively select online supplementary learning materials for learners based on their progress and performance levels. Secondly, it can facilitate an instructor in carrying out ongoing assessments, which benefits both instructor and learners. On one hand, the instructor can closely monitor learning progress and make appropriate adjustments based on learner performance and needs. On the other hand, the learners can promptly identify their areas of strength and weakness. Lastly, the system helps support the instructor in the transition from a traditional face-to-face classroom teaching and learning to a blended learning model without substantial change in the instructor's role and instruction methods; thereby reducing potential resistance to change and enabling the instructor to quickly and comfortably adapt to the new mode of teaching and learning.

The system has been introduced and tested with a group of undergraduate students and an instructor in an experimental classroom, equipped with WiFi connection. There were twenty student participants, half of which studied IT-related degrees and the others were from non-IT related programs. A Mathematics course (i.e., pre-calculus) was experimented. The students and instructor used their personal mobile devices to run the client application, connecting to the system during the teaching and learning session. Prior to the beginning of the session, a quick demonstration of the application and its functionalities were introduced. During the session, the instructor and students used the application as part of the instruction and classroom activities. At the end of the session, the students preliminarily evaluated the system usability.

The results have yielded that the system is easy to use, and can effectively support the learning process as well as improve student engagement. The majority of the obtained comments indicate positive feedback both in term of simple-to-use user interface and dynamic presentation of supplementary learning materials. Some minor comments for improvement include the need for theme customization for different end-user devices and the ability to randomly generate exercise questions.

Future work aims at improving the system functionalities as well as performing a detailed evaluation on the effectiveness issues through a real-world classroom environment.

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