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Collaborative Learning under an Adaptive Web-based Architecture

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Abstract. In any one class, there are differences between students' abilities, interests, achievements, preferences and learning behaviors. Some need a challenging class, promoting their level. Some of them want to keep to the working routine. Others need to be taught very slowly. This situation is particularly notable in mathematics instruction. Many teachers feel frustrated because they want to provide for all students' needs and abilities but are constrained by time and space. In this study, we propose an adaptive web-based learning architecture, based on a collaborative model and a tutor model, to help solve the problem. Students can learn at their own pace, constructing knowledge by collaborative learning and using tutor assistance to solve their problems immediately. The research on our learning architecture was conducted with fourth grade primary school students learning fractional operation.

Key words: Collaborative, adaptive, tutor assistance, web-based, e-learning in classroom

INTRODUCTION

Learning via electronic appliances on the Internet is called e-learning also known as distance learning, on-line learning (training) or Web-based learning[1]. It enables learners to learn by themselves. According to the analysis of the International Data Corporation (http://www.ide.com), the world wide corporate e-learning market will exceed US$24 billion by 2004. The reason for this rapid growth is that e-learning provides a convenient and efficient learning environment; useable at anytime in any place. Many universities[2], corporations[3] and educational organizations[4] are developing distance learning platforms to provide course materials for Web-based learning[5]. And more and more academic communities are investing in web-based learning research, developing a variety of experimental learning systems. Some focus on personalized e-learning systems[5], some on adaptive systems based on cognitive style[6], some on collaborative model systems[7,8] and some on tutor-web systems[9].

Several problems exist in the process of teaching in the traditional, non electronic classroom. With limitations on space and time, it is very difficult for one teacher to provide equally effectively for all students in a class given their differing abilities, interests, preferences and learning styles. The reiterative and simultaneous characteristic of e-learning system improves above problem and promotes adaptive learning.

Collaboration refers to activities that are related to how the group is functioning in accomplishing a task, Collaborative learning provides an opportunity for the group members to regulate their collaboration process[10]. Within collaborative learning, the responsibility for learning shifts from the teacher to the group member[11]. Higher order of psychology process is internalized from external social activities. The whole psychological development structure starts from external social activities and terminates at individual's internal activities. Social activities, especially interpersonal conversation, self-examination and thinking development, facilitate one's internalization process through interpersonal conversation[12]. Rorty[13] also contended that a person will make conviction after contact with the external environment, but it has to become fact through defense and then become knowledge. Much recent educational research has emphasized the importance of conversations in the classroom[14]. A collaborative design environment enables team members to share information and to coordinate their activities within the context of a design project [15]. Implementing collaborative learning in a web-based system could promote more effective and efficient learning. The conversation could be the comments and feedback from peers; the collaborative learning mechanism.

We see the problems of traditional classes clearly and see the benefits of class-based e-learning. Bearing in mind

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the limited budget of most schools, we propose a collaborative learning system using an adaptive Web-based architecture, combining a curriculum model, a collaborative learning model and a tutor assistance model. Arranging curriculum adaptively and aggregating developing mature software systems, promoting effective and efficient e-learning system in using real class.

SYSTEM PROPOSED

First, we introduce the system architecture. Our proposed system includes three models. After that we explain these three models and the process in our proposition in detail. Our research proposal was based on the fourth grade mathematics curriculum of elementary education in Taiwan. Fractional addition and subtraction operation was our experimental curriculum.

System architecture: Our proposition uses three models: a curriculum model, a collaborative learning model, a tutor assistance model. Learners access the curriculum model by web browser (Fig. 1). Through the curriculum model, learners can enter the collaborative learning model and the tutor assistance model as they need them.

Through the interaction of the three models, students construct knowledge and solving doubts by giving comments to and getting feedback from peers and by getting help through communication with the tutor at any time. Learners will feel that learning in class is not only listening any more, they will have more chances to get real practice and they can bring up their thoughts and doubts at any time. The tutor will be better able to instruct a greater number of individual students in more depth than in the traditional system. At the same time, the instructor or tutor have more possible to instruct individual cases in one class that be consisted by quite a few of students.

Curriculum model: Mathematics text books in Taiwan are arranged in a horizontal way, meaning that they include different concepts within one book. For example: operation of addition and subtraction, operation of multiplication and division, calculation of area and volume, fractions, etc. They do not progress vertically from simple to difficult. In our proposed system, the formation of curriculum model provides for three difficulty levels. Cl_i, Cm_j and Ch_k represent low, medium and high level curriculum, respectively (Fig. 2). Low level curriculum had been taught in prior grade, moderate level curriculum suits this grade, high level curriculum will be taught in the future grade. Each curriculum level includes one concept web and several exercise webs. The exercise webs include fundamental operation exercises and application problem exercises. Considering the learners' individual differences in learning, achieved abilities and cognitive styles, we propose an adaptive function where, learners could select an appropriate curriculum. Our experiment focuses on fraction concept learning.

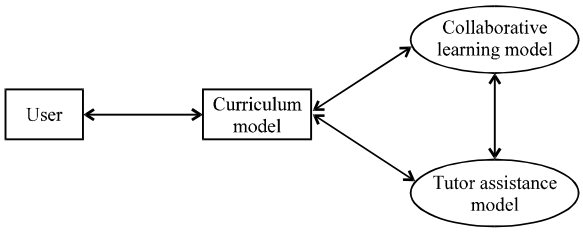

Fig. 1: The system architecture with three models

Collaborative learning model: Each curriculum web relates to one collaborative learning web. Fl_i, Fm_j and Fh_k represent the collaborative learning webs related to Cli, Cm_j and Ch_k in the curriculum model (Fig. 2). Learners can link to the collaborative learning web in each curriculum web and can leave their comments, critiques or thought and construct their knowledge by discussion in the web. The collaborative learning web is arranged by date in decreasing order so that learners can browse recent comments instantly when they enter the web. Concerning implementation, we recommend free and mature software to achieve collaborative learning, such as Weblog or Wiki. Our research was implemented using the Weblog system.

Tutor assistance model: Tutor assistance is necessary in the web-based learning system for timely and appropriate5 solution of learners' problems. In our proposed system, each exercise web can call the tutor assistance model through the click of a bottom. Considering finite expenses, we propose free, easy-to-use, convenient-to-access public software such as: Yahoo! Messenger, MSN Messenger, or Skype. In our implementation, we aggregated Yahoo! Messenger in our system. Learner can bring up their doubts in private by typing, or by speaking through a microphone.

Process of our proposed learning system: The learning process in our system is presented in Fig. 3. We classify it into 5 steps.

Step 1: Learning stage. All participants enter the system and in the style of a traditional class, the teacher plays the role of instructor and guide. After concept presentation, the teacher will give some examples.

Step 2: Communing with self stage. After practicing, learner judges the difficulty of the material and selects appropriate exercises and problems him/herself.

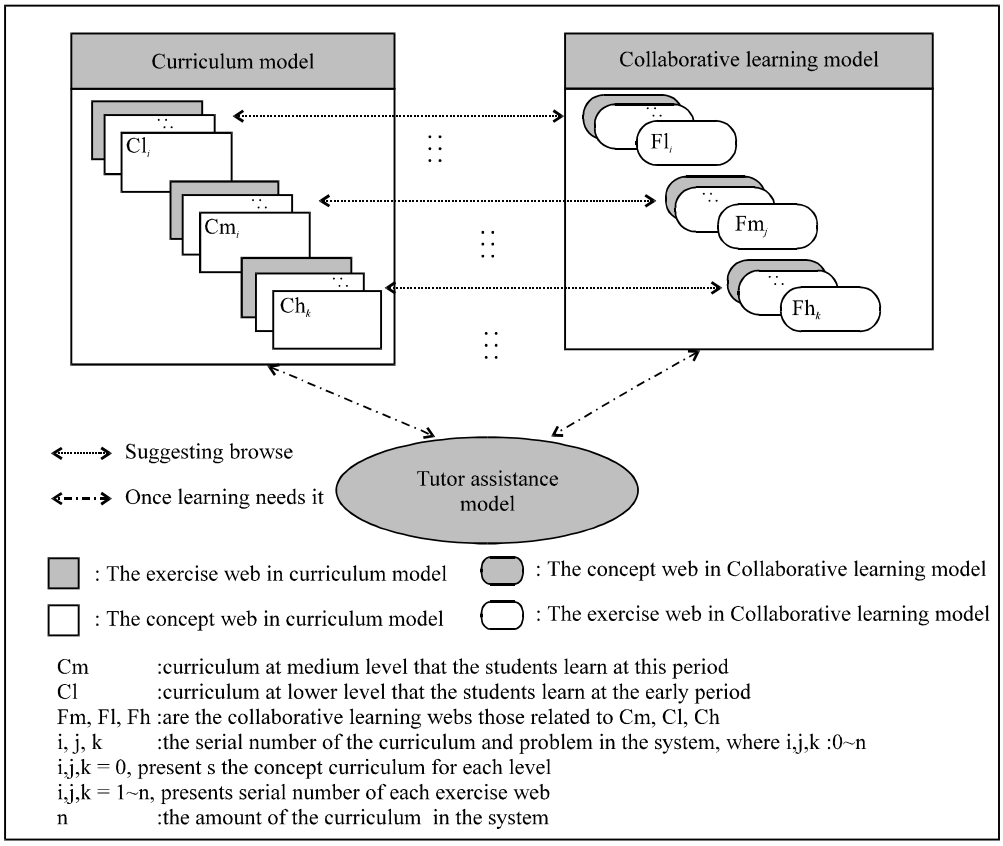

Fig. 2: Three related models

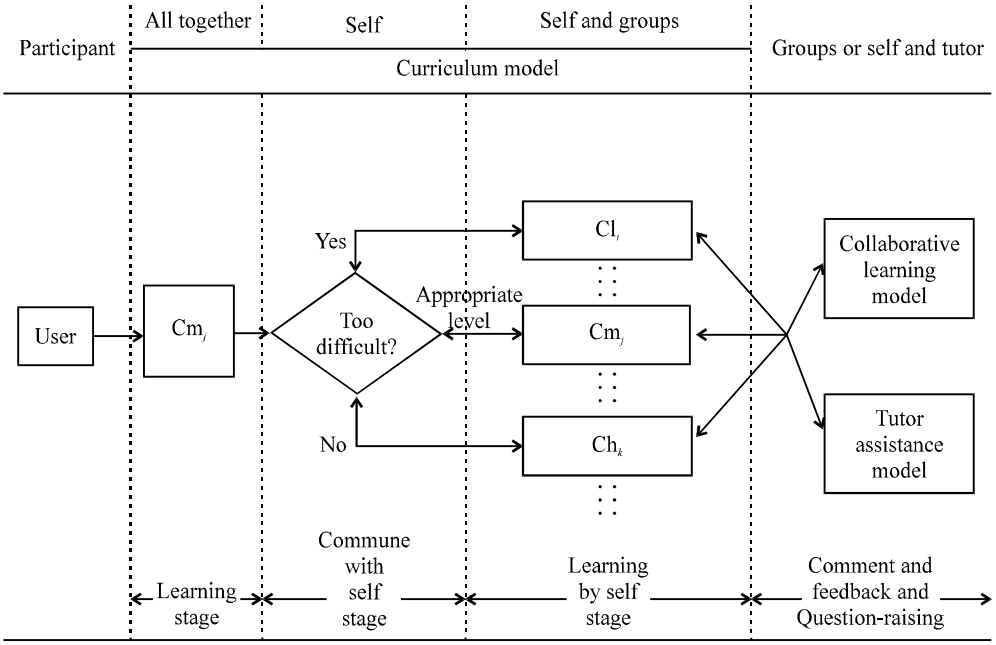

Fig. 3: Flow chart of the proposed learning system

Step 3: Learning by self stage. All learners enter the appropriate exercise or problem

web. Learner may be in the web alone or with peers at the same time. Using the exercises at different levels and in different patterns, learner constructs his/her own knowledge.

Step 4: Comment, feedback and question-raising stage.

- If learner has any comments or doubts, he/she can enter the collaborative learning model and leave their thought or doubt in the related collaborative learning web for each curriculum.
- Learner enter tutor assistance model, if he/she wants to clarify concepts with the tutor.

Step 5: Learning alternates between step 3 and step 4, providing adaptive leaning in peer cooperation and tutor assistance.

IMPLEMENTATION AND COMPARISON

This section describes our implementation and the layout of our proposed learning system; it includes the layout of the curriculum model and the interface of the collaborative learning web. It represents adaptive learning, collaborative learning and tutor assistance in our proposed learning system. We go on to compare our proposed learning system with other published systems.

Experimental environment and interface: Our proposed learning system was implemented in Microsoft Windows Server 2000 using an IIS 5.0 Web server. Figure 4 presents the entire layout of the curriculum web interface. It is separated into two parts. The first part is to the right of the window, a presents the content of curriculum including concept learning web and exercise web. When user enters the exercise web, the button for calling the collaborative learning system will appear. The collaborative learning web was implemented using the Weblog system (Fig. 5).

Field dependence/independence (FD/FI) is probably the most well known division of cognitive styles[16]. Field dependence–independence has important implications for an individual's cognitive behavior and for his/her interpersonal behavior. Adaptive navigational support suits the FD learner, whereas a content menu suits the FI learner[6]. The content menu relates to our adaptive curriculum catalog which we will discuss next paragraph.

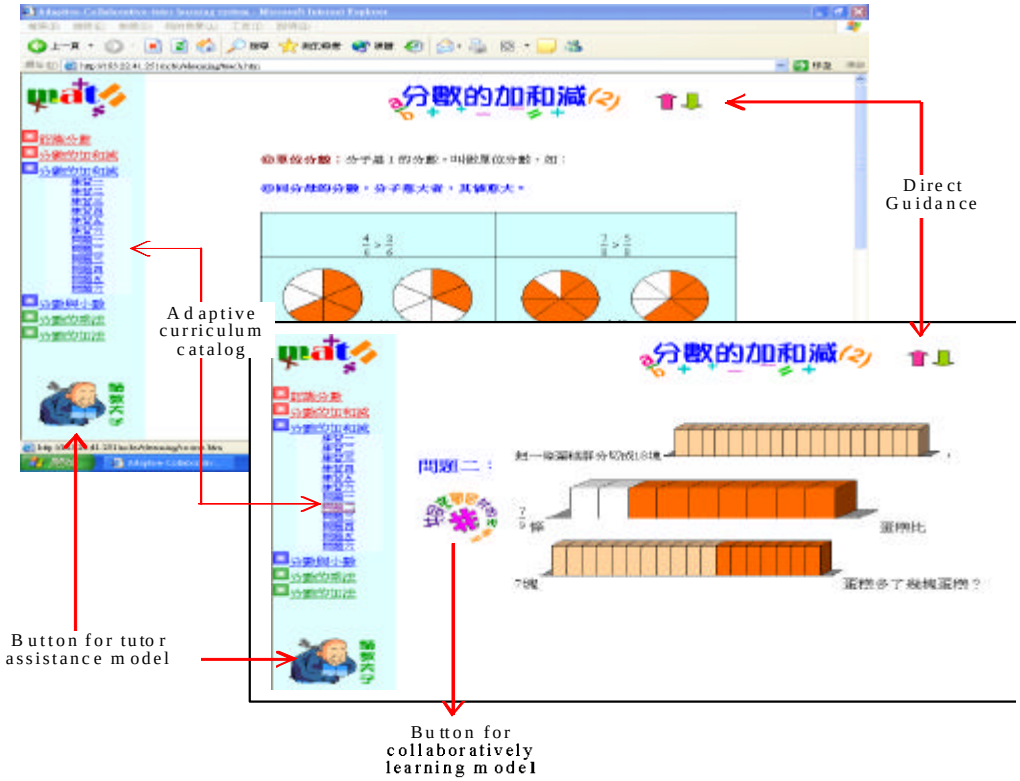

Fig. 4: The layout of curriculum model

Fig. 5: The list of the comment for one exercise in the interface of collaborative learning web

Fig. 6: Comment writing interface in collaborative learning web

There are two arrows for the direct navigation in the upper right part of part window. The up-direction arrow hyperlinks to a lower level exercise web; the down-direction arrow hyperlinks to a higher level exercise web. With the direct navigation, the system suggests to the student the next part of the learning material.

The second part is to the left of the window and presents the adaptive curriculum and the button for the tutor assistance model. This button hyperlinks to the tutor system. We implemented this using Yahoo! Messenger. The formation of adaptive curriculum catalog is from easy to difficult from up to down.

We also use colors to differentiate the curriculum levels. This helps the user to find a suitable curriculum quickly. Red represents the lower level curriculum, which the learner had probably learned in the previous grade. This curriculum level helps the lower achievement group to rebuild their knowledge foundations. Blue represents the medium level curriculum; it suits the fourth grade students and the teacher instruct at this level. Green represents the higher level curriculum which learners will be taught in the next grade. This curriculum level guides the higher achievement group to expand their knowledge by them. Figure 5 shows the interface of collaborative learning web for one example curriculum level. The interface listed all comments and feedback arranged by date in decreasing order, so the most recent comments are at the top of the list. Figure 6 presents the comment-writing interface, which is called from the list in Fig. 5.

COMPARISON AND DISCUSSION

As techniques of using computer networks have developed and become widely used, many academic communities have invested in the e-learning field and developed various kinds of learning system. Here, we list three published systems and compare them with our proposed learning system.

- AHS: Adaptive Hypermedia System. The design and the formative evaluation of an adaptive educational system based on cognitive styles[6]. The system can be developed to accommodate a variety of individual differences, including learning style and cognitive style, in order to improve students' interactions and learning outcomes. To facilitate on adaptive learning system, they provide different user interfaces and browsing supports for FI/FD students.
- PEL-IRT: Personalized e-learning system using Item Response Theory[5]. A personalized e-learning system based on Item Response Theory which considers both course material difficulty and learner ability to provide individual learning paths for learners.
- Multimedia whiteboard system: Development and evaluation of multimedia whiteboard system for improving mathematical problem solving[17]. This system is an online mathematical learning model where students not only use electronic whiteboards to write down their mathematical problem solving solutions but also use voice recording tool to give oral explanations about the thinking behind the solutions. It provides a collaborative learning environment.

Table 1: Comparison among 4 systems

	Adaptive learning considers learners' abilities	Adaptive learning considers cognitive style	Collaborative learning	Tutor assistance
AHS (A)	---	□	---	□
PEL-IRT(B)	□	---	---	---
Multimedia whiteboard system (C)	---	---	□	---
Our system	□	□	□	□

□ □: This property exists in the system
--- □: This property does not exist in the system

AHS, PEL_IRT and the Multimedia whiteboard system each provide for different learning factors (Table 1). Adaptive learning considering learners' abilities and cognitive styles, collaborative learning and tutor assistance are the important factors to promote effective and efficient learning. Our proposed learning system takes into account all of these factors.

CONCLUSIONS

Web-based learning systems and electronic learning materials allow users to repeat exercises and to learn simultaneously. This learning model helps overcome the limitations of time and space in the classroom. It also promotes adaptive learning in a class with one teacher and many students. But collaborative learning and tutor assistance have rarely been integrated into web-based learning systems until now.

We propose a new web-based learning architecture. This architecture emphasizes models; adaptive learning, collaborative learning and tutor assistance. Our adaptive curriculum framework makes use of existing mature software systems, promoting effective and efficient learning.

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