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ABSTRACT

This paper describes the design and features of LEA (Learning Environment with Agent), an educational system which has the features of both synchronous and asynchronous group learning environments. The first section discusses group learning environments, including differences between individual learning and group learning, and the classification of group learning according to the style of communications. PSM (Public Student Model), a new student model that allows students to grasp their understanding level, is proposed in the second section; PSM consist of three modules that store student information--an understanding model, a learning history, and a question database. The third section deals with LEA, including system configuration (virtual space, the agent, and the agent control module), learning in virtual space, and learning through the agent. In the conclusion, problems with PSM and LEA are summarized. A table presents features of synchronous and asynchronous group learning environments; two figures illustrate the system configuration of LEA and LEA virtual space. (DLS)

Group Learning Environment Linking Synchronous and Asynchronous Learning

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Abstract: The style of computer based educational systems has been changed from individual learning to group learning, cooperative learning, collaborative learning and so on. In the viewpoint of architecture of the computer based educational systems, network typed educational systems have been developed using network and multimedia technologies. We are currently developing an educational system called LEA: Learning Environment with Agent which has the features of both synchronous and asynchronous group learning environments. This paper describes the design and features of LEA.

1. Introduction

Recently, the learning style which computer based educational systems deal with has been changed from individual learning to group learning, cooperative learning, collaborative learning and so on. In the viewpoint of architecture of the computer based educational systems, network typed educational systems have been developed using network and multimedia technologies. Watanabe et al., whose work is called the Global Classroom Project [Watanabe et al 1995], introduced Internet applications into classes at junior high schools in Japan. Nakabayashi et al. developed an educational system using WWW (World Wide Web) [Nakabayashi et al 1995, Soga et al 1995]. Ayala and Yano developed a CSCL system called GRACILE which supports communications by software agents[Ayala & Yano 1994].

The purpose of these works is to develop computer based educational systems which offer group learning environments. Since discussion among students is the most substantial part in all group learning processes, it is very important for the educational systems to have functions for supporting communication. These functions are classified into two categories: one offers the means of communication and the other supports smooth discussion. CU-SeeMe is an example of the former. The discussion supporting system called iDCLE developed by Inaba *et al.* [Inaba & Okamoto 1995] is one of the latter examples.

In general, communications are classified as synchronous and or asynchronous. The former type is realized by using synchronous communication tools, and the latter type is realized using asynchronous communication tools such as electric mail, electric bulletin boards, and so on. The aim of most existing communication tools is to support only the synchronous type. Group learning environment are classified in the same way as communications. Students can learn more effectively in a synchronous group learning environment than in an asynchronous group learning environment, because they can exchange their opinions, ideas, and so on through real time, interactive communications. However, synchronous group learning environments have a serious problem with schedule management. While students in an asynchronous group learning environment do not need to manage their schedules. So this is a point where asynchronous group learning is superior to synchronous group learning. Students may learn in both types of group learning environment according to their needs. Therefore educational systems for group learning environments should support both synchronous and asynchronous types.

Group learning progresses through discussions among the students. So the quality of discussions among students significantly influences the effectiveness of group learning. Since the discussions are more effective if each student can grasp their understanding level, we propose a

new student model called Public Student Model (PSM) which makes students aware of it. A student model of ITS (Intelligent Tutoring System) does not make students aware of their understanding level. With respect to this, PSM is different from student models of ITS that do not provide this information to students.

We are currently developing an educational system called LEA: Learning Environment with Agent which has the features of both synchronous and asynchronous group learning environments. This paper describes the design and features of LEA.

2. Group Learning Environment

This section describes the features of group learning environment. From the viewpoint of a student who is participating in learning environment, some other students exist in the group learning system and do not in the individual learning system. A student has educational interactions with other students in order to promote learning. Therefore, communication among students is important in a group learning environment.

2.1 Differences between individual learning and group learning

In a group learning environment, students can use the knowledge of other students as a human educational resource that does not exist in an individual learning environment. Therefore, to get the knowledge of other students, discussions among students are essential, and through the discussions, they can learn the subjects at hand more effectively.

Group learning environment progresses via interactions among students. Other students could act as a human educational resource according to their understanding level. In this point, they are different from the traditional resources such as textbooks, dictionaries, and so on. In order to get the understanding level of other students and to behave educationally, a student must present their own opinions and points that s/he does not understand. Therefore, the discussion among students are very important in a group learning environment. The quality of communications among students influences the quality of group learning, because the main difference between an individual learning and a group learning environment is the existence of other students. This feature is the basis of the advantages of the group learning environment.

2.2 The classification of group learning according to the style of communications

In a group learning environment, communications are important. As described above, communications are classified into two types: synchronous type such as a video conference system, a chat application, and so on, and asynchronous type such as electric mail, electric bulletin boards, and so on. Group learning environments are classified according to the type of communications used as synchronous group learning environments, or asynchronous group learning environments, because the discussion among students is most significant feature in a group learning environment. Table 1 shows the features of each group learning environment.(GLE means Group Learning Environment in the table) .

Table 1: Features of synchronous and asynchronous group learning environments

	Synchronous GLE	Asynchronous GLE
Learning style	tends to *Collaborative Learning*	tends to *Individual Learning*
Schedule management	necessary	not necessary
Response time	short	long
Quality of communication	good	bad

Synchronous group learning environments tend to have the style of collaborative learning in which members of the group collaborate with each other solve problems by means of real-time,

interactive communication. On the other hand, in asynchronous group learning environment, a quick response from each student cannot be obtained. Therefore a student learns asynchronously with others, when they need others' helps. it is also difficult for students to communicate well in asynchronous group learning environment, because few cases hold common contexts of students' utterance each other, response time is long and so on. However, students do not need to manage their schedules in an asynchronous group learning environment. On the other hand, students in synchronous group learning environment must manage their schedules, and this management becomes more difficult as the group size grows.

3. Public Student Model

In general, the more deeply each student can grasp the understanding level of other students in the same learning group, the more efficient the group learning becomes. Focusing on this point, we propose a new student model called PSM: Public Student Model which allows students to grasp their understanding level.

3.1 Grasping other student

A student can learn effectively in a group learning environment, if s/he can have many opportunities to interact with other students. In this case, other students behave as a human educational resource for the student. However, this human resource is not the same as the traditional representative resource such as textbooks, dictionaries, and so on, because the former resource can behave educationally by grasping their own understanding level and that of other students. In other words, other students are a flexible and adaptive resource. We especially believe that it is important to grasp the understanding level of other students in order to behave as good human resource in group learning environment. Recently, many CSCL systems have been proposed and developed, but there are few CSCL systems that emphasize on this point.

Focusing on the point described above, we propose to open each student model that represents the understanding level of a student in a group learning environment to other students. General student models in ITS and so on can only be referred to by the educational system to identify and infer the understanding level of student[5]. Our approach provides students rich information necessary to grasp the understanding level of other students. PSM has the database which stores the information, and all students in a group learning environment can access this database.

3.2 Information about student in PSM

PSM consists of the following modules that store the student information and are accessed from other students in a group learning environment: (1) an understanding model, (2) a learning history, and (3) a question database. The understanding model presents the understanding level of student. Other students can access this model freely so that they can easily grasp what understanding level the student has already achieved. In addition, a student can also access their own understanding model. This suggests a possibility for the student to use it for her/his reflection and then amend his/her own knowledge by her/himself, although our current system does not help students with this task.

The learning history holds the sequence of the student's actions. Tracing the learning history, other students and also the system can identify the cause of errors and misunderstandings by the student.

The question database is also open to other students. A student can put her/his questions in their own question database. Other students can access this database and put answers into it. In this way, the question database can be used as a temporary memory for asynchronous question and answer.

4. LEA: Learning Environment with Agent

As described in Section **2**, learning environments are classified as either synchronous or asynchronous. We conjecture that learning environments should have the features of both types in order to compensate the defects of each type. Group learning environments that have both synchronous and asynchronous properties allow students to be absent temporarily from the system. To allow the absent student to learn from the results that were obtained during her/his absence, we introduce an agent that plays the role of absent students. In section **3**, we proposed the PSM in order to aid in effective group learning. To satisfy the requirement, we are developing the new learning environment called LEA: Learning Environment with Agent. In the following, we outline LEA and describe its goals.

4.1 System configuration

Figure 1 shows the configuration of LEA system. LEA offers a virtual space and an agent for each student. Every student manipulates their agent to learn in the virtual space. Next, we describe the functions of main modules in the LEA system in the followings.

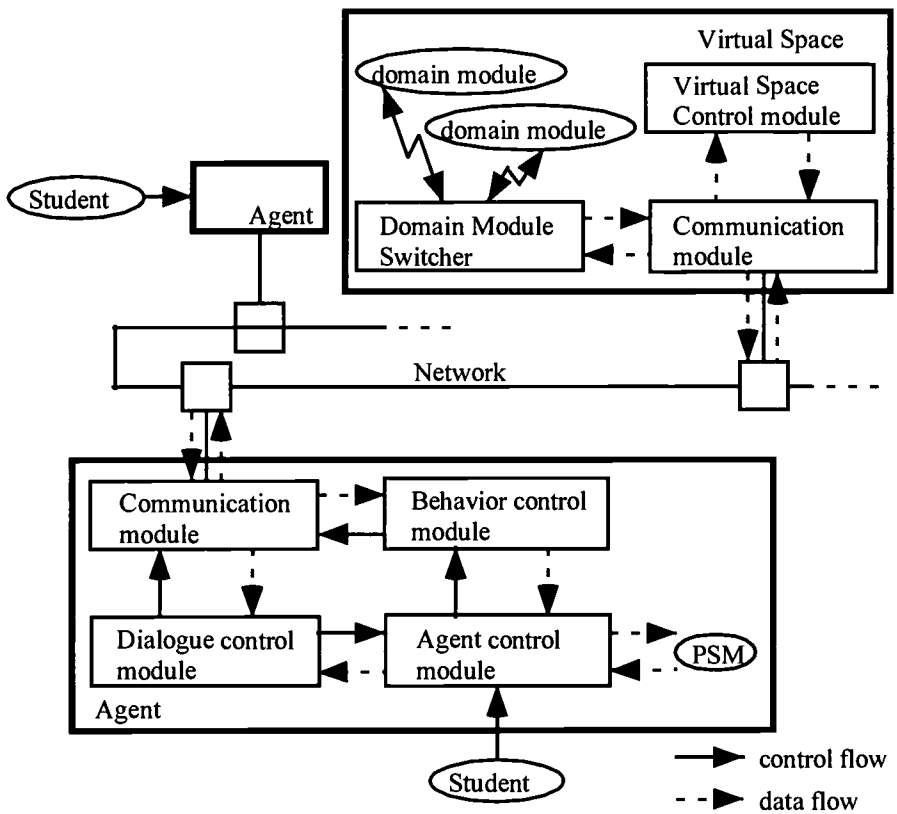

Figure 1: System configuration of LEA

4.1.1 Virtual Space

In the virtual space (LEA group learning environment), every student learns her/him subject(s). There are domain modules in the virtual space. The domain module provides educational tools for specific domain. For example, the domain module for mathematics offers virtual ruler, compass and so on.

4.1.2 Agent

Each agent may be in either marionette or normal mode. In marionette mode, a student can completely manipulates the agent to learn in the virtual space. On the other hand, in normal mode, the agent simulates educational activities an absent student without her/his manipulations. An agent can report the performances taken during the normal mode to the client student, when the student uses LEA again.

4.1.3 Agent Control Module

This module controls the activity of an agent and decides an agent behavior based on commands which the student set in advance. Then, the agent executes educational action of the absent student in the normal mode.

4.2 Learning in virtual space

LEA system contains a shared virtual space and students' agents. Each student has one own agent. Students behave as virtual people in the virtual space. The students gather potential members, make a learning group, and learn their common subject(s) in a classroom of the virtual space. The virtual space provides classrooms for each domain. Each classroom is separated into small rooms based on fields, groups and so on. In this way, the virtual space is structured as a hierarchy of fields, groups and so on. This structure makes it easy for students to look for members and groups interested, because LEA is not a domain dependent system and group learning about some domain is feasible in the virtual space offered by LEA. In addition, LEA has a function to show the members of each group and the theme to be discussed. Figure 2 shows an example LEA virtual space.

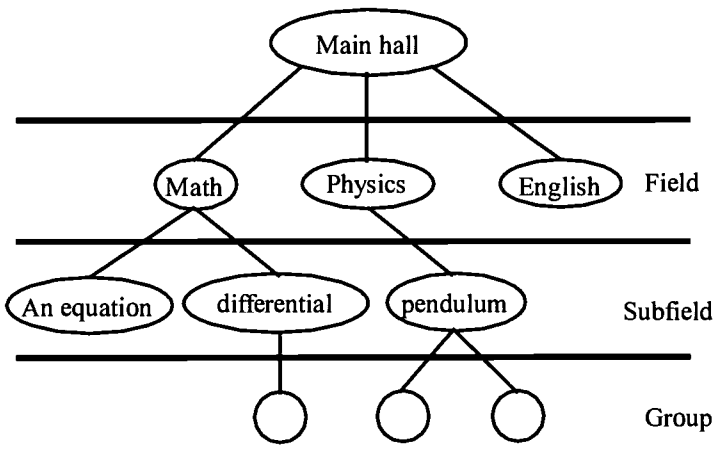

Figure 2: LEA virtual space

4.3 Learning through agent

An agent has two modes: marionette and normal mode. Students can use these modes according to their needs. In the marionette mode, manipulating an agent, students gather potential members, form a learning group, and learn subject(s). In this mode, they learn synchronously. On the other hand, in the normal mode, an agent supports students who cannot participate synchronously. In this mode, an agent asks questions and participates in the group learning which is selected by the absent student. The agent reports the contents of thhe learning sessions perform during the normal mode to the client student, when they return to the LEA. In this mode, students learn asynchronously.

In the LEA, students behave as virtual people and the system does not show the personal information of students. Hiding the information makes students evaluate other students properly through their actions in the virtual space only.

We adopt PSM model as a student model for group learning. So, students can use the knowledge of other students by accessing the other students' PSM as an educational resource. Students who participate asynchronously can learn more deeply, since their knowledge is reflected to the group learning.

5. Conclusions

This paper described LEA that supports both of synchronous and asynchronous group learning. In LEA, students can learn in the virtual space. LEA makes possible to bridge between synchronous and asynchronous group learning, since students can learn synchronously and asynchronously by using agent in two modes. We have proposed PSM which is a student model for group learning, and adopted it in LEA. Students can discuss effectively, since PSM makes their level of understanding available to other students. However, we have some problems with PSM and LEA that remain to be solved are described.

PSM inherits the same problems which traditional student model has, such as how dose the system generate excellent model, how does problems to solve the model. Besides, there are problems with to get the necessary information to make PSM from discussions among students and how to model students, how to represent the understanding model so that other students can grasp the understanding level of a student. Developing LEA has two big issues. The first problem is how to realize behavior of an agent in the normal mode. It is desirable to have the behavior of an agent in the normal mode be the same as behavior in the marionette mode. Although, it is hard to make such an agent completely by employing state-of-art AI technologies, we are currently considering the alternative method using current technology. The other problem considers LEA group learning environments where students participate synchronously or asynchronously, simultaneously. In such situations, the existence of students who participate asynchronously in Synchronous Group Learning may confuse other students who participate synchronously. We will consider this problem through experiments with a prototype of LEA. In this way, as our future works, we will solve those problems of PSM and LEA, and consider the learning style bridging synchronous and asynchronous group learning.

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