This is a reprint from a paper published in the Proceedings of the IADIS International Conferences IADIS, http://www.iadis.org
ASSISTING LEARNERS TO DYNAMICALLY ADJUST LEARNING PROCESSES BY SOFTWARE AGENTS

Weidong Pan
Faculty of Information Technology
University of Technology, Sydney
PO Box 123 Broadway, NSW 2007, Australia

ABSTRACT
This paper presents an agent-based approach to assisting learners to dynamically adjust learning processes. The online learning process is first investigated where the importance of learning plans as support to online learning is highlighted. A way to help learners develop personalized preferred learning plans and guide them throughout the plans is outlined. Then, the related implementation techniques are described.

KEYWORDS
Online learning, adjustment of learning processes, learning plans, knowledge construction, constructivist methods of learning, software agents

1. INTRODUCTION

Constructivist learning is being recognized by more and more people as a productive learning method. Although there are diverse constructivist paradigms, they have commonly epistemological assumptions for learning (Fosnot, 1996). The fundamental epistemological assumption is knowledge cannot be transmitted to learners but must be individually constructed and socially co-constructed by learners (Jonassen, 1999). Because constructivist learning focuses on knowledge construction, it can generate more significant results than other methods such as the objectivist ones (Wilson, Teslow and Osman-Jourchoux, 1995).

According to constructivist theories for learning, learners are active knowledge-constructors, whereas teachers are cognitive guides who provide guidance and scaffolds to support the construction (Mayer, 1999). Unfortunately most current online instructional systems have not really taken such roles. Mostly they just simply deliver online course materials over the Internet without providing effective guidance on how to use these materials to construct knowledge. As a result, learners only passively receive information from the presented materials. They have not been engaged in actively constructing meaningful understandings of the study theme. This research is aimed, through incorporating software agents into the online learning environment, to actively assist learners to construct knowledge by using constructivist methods.

The research into software agents has been a rapidly developing area of research. Already a lot of agent based systems have been proposed ranging from comparatively small systems such as personalized email filters to large, complex, mission critical systems such as air-traffic control (Jennings, Sycara and Wooldridge, 1998). In particular, pedagogical agents have been developed to take the role as a virtual tutor or a virtual learning partner, etc. The agents we are developing will facilitate online learning through the comprehensive applications of the properties that agents can provide, such as autonomy, learning, cooperation, reactivity, goal-driven, etc. They will work together coordinately to facilitate effective knowledge construction for individual learners. Our agents assist learners to construct knowledge not through understanding the academic content of subjects, but rather through providing a wide range of services. These services include: 1) providing access to appropriate learning resources and learning strategies; 2) fostering meaningful interactions with content, teachers, and fellow learners; 3) supporting personalized learning for individual learners; 4) promoting collaborative learning among learners; and 5) aiding to timely and accurately evaluate learning achievements.
This paper is focused on showing how software agents are applied into assisting learners to dynamically adjust learning processes. This includes: 1) guiding them to develop personalized preferred learning plans that satisfy their learning needs and match to their particular learning styles; and 2) assisting them to timely align learning plans according to the real progress of learning. The purpose of such kind services is to engage learners in knowledge construction and promote its success through providing guidance for learners to solve the problems pertaining to learning strategies which they often meet with in online learning.

2. A WAY TO ASSISTING LEARNERS TO DYNAMICALLY ADJUST LEARNING PROCESSES

2.1 The Online Learning Process and the Learning Plans

Online learning takes place in many environments rather than just at education institutions. Learners in education institutions usually follow a particular instruction program. Other learners however build their knowledge through a continuous and guided process of identifying learning project goals, discussing and trying ideas and evaluating learning outputs. Such a process, as shown in Figure 1, is initiated and driven by a learning goal. After a goal is constituted based on a project or a case under study, learners experience a guided process to reach it. The first step is to build a plan to achieve the goal. This includes defining the learning activities to be taken and designing the methods to conduct these activities based on their particular cognitive features and learning history. Then, learners carry out the plan to construct their knowledge. They follow the learning steps in sequence as defined in the plan. These learning steps are various learning activities, e.g. accessing to learning resources, discussing with others, doing assignments, doing self-assessments, requesting assistance from others, etc. While the learning is progressing, learners manage the plan to timely align learning towards their goal. They record their own learning activities, evaluate their outputs, and then revise the current plan based on the evaluation. The updated plan will immediately affect the learning process; the relevant activities or sequences will be aligned. The learning based on the updated plan will be evaluated again and then further result in a plan revision. An online learning process proceeds in this way until the evaluation shows that the learning goal has been achieved.

2.2 The General Framework for Supporting Online Learning

As described above, the major challenges for learners to take part in online learning include: 1) building an appropriate learning plan to achieve their learning goal; and 2) timely and accurately adjusting the learning plan towards the goal based on the practical learning progress. It will significantly benefit learners to continue their pursuits for the goal if the online instructional system can provide assistance for them to tackle these challenges. This is because not all learners are equally capable of adequately addressing these challenges on their own (Large, 1996). Some may lack of necessary prior knowledge or abilities to
independently define the needed learning activities and choose a proper method to conduct them. Some may have no ideas of how to evaluate the outcomes of learning and vary plans according to learning progress. What degree of the assistance is suitable for helping learners to deal with such problems? Is it suitable to take full control of the learning by the online instructional system? Some intelligent tutoring systems (ITS) utilize learner models, expert models and tutorial models to simulate learning processes and make all decisions for learners based on these models. The problem is that these models cannot possibly specify all of the ways in which learners may go about trying to solve a problem (Jonassen, 2000). This is because learners never learn using a same way due to their different backgrounds, interests, styles, motivations, capabilities, etc. It is even more true for online learning because most of the online learners are adult learners. As a result learners in those systems are often forced down the pre-set learning plans that do not suit them, or even limit the development of their cognitive abilities.

In order to provide personalized learning experiences for individual learners and make the learning process optimal, learners must be assumed responsibilities for some decisions in the process. Active learning must be encouraged. Learners construct knowledge only by active learning (Akhras and Self, 2000). Therefore, we have utilized a novel strategy to helping learners in which the system allows learners to actively construct knowledge and meanwhile the system actively provides services to direct and scaffold the process. Those are not only directly aimed to solve the problems emerged in practical learning scenarios but also are customized to the personalized needs of learners according to their unique learning characteristics.

In the proposed instructional system, learners are not imposed to take any learning steps. They can thus independently develop and explore their own learning plans for the study themes and actively construct meaningful understandings of the themes. Their autonomy in learning has been supported and encouraged. Meanwhile the system offers suggestions or advices for directing them to develop learning plans and vary learning plans while they have troubles with these things. This contrasts with most current online instructional systems, which just present course materials and leave learners themselves to determine how to achieve their learning goals. On the other side, this also contrasts with those ITS where learners can only passively follow a preset learning plan chosen by the system.

2.3 An Approach to Assisting Learners to Dynamically Adjust Learning

In order for the online instructional system to provide customized services to meet an individual learner's just-in-time needs or even just-for-me needs in online learning, knowledge about the learning activities being conducted, the practical learning progress and the learner's learning styles is necessary. It thus requires combining learning content and learning evaluation with the service components together. A UOL (unit of learning) database is being used to implement the combination.

A UOL is a learning unit that satisfies one or more learning objectives. It may correspond to a course, a module, or even a single learning activity such as a discussion to elaborate on some topic. The UOL database is built by a series of carefully designed learning scenarios where not only the learning content and evaluation methods are specified but also the relevant learning activities, the conduct sequences and the supportive services for various types of learners are defined as well. The structure of the UOL database is designed based on a UOL specification language which is developed by us through extending and adjusting the EML (Koper). Our specification language has been reported in (Pan and Hawryszkiewycz, 2004).

The service components are implemented by software agents. The agents are responsible for providing suggestions or advices according to the real learning progress and learner styles. Any change taking place in

![Diagram](image)

Figure 2. The architecture of the online learning system
the learning environment made by one or more learners is detected by the agents. The learning progress is evaluated through evaluating the detected events. The learner profiles are built and timely updated through collecting the detected events and inducing by them. The agents take the practical learning scenarios and the learner styles as input and generate suggestions or advices on what should be done for learners. They are mainly based on the knowledge extracted from the UOL database by matching the input to the learning scenarios in the UOL database. The overall system architecture is shown in Figure 2.

3. THE AGENT IMPLEMENTATIONS FOR GUIDING LEARNERS TO ADJUST LEARNING PROCESSES

3.1 Assisting Learners to Develop Personalized Learning Plans

The plan agent in the multi-agent architecture is responsible for assisting learners to develop personalized plans to reach their learning goals. The assistance is implemented through advising them several plans for achieving their goals. These plans are the methods to conduct learning, including the relevant learning activities to be taken and their conduct sequences. They are extracted from the UOL database based on the practical learning scenario and the specific learning characteristics of the learner. As shown in Figure 3, the agent first determines a UOL by matching an individual learner's goals to the objectives of a UOL in the UOL database. Then it captures the learning methods for the UOL from the database. Next it further determines the ones from them that are suitable for the learner according to the fit degree of the method for him. Finally it presents these methods as the recommended learning plans.

The following technique is used by the agent to identify if a particular learning method is suitable for a learner and to measure the fit degree. The learning property of a learner, stored at his cognitive profile, is characterized by a set \( P = \{ p_1, p_2, \ldots, p_n \} \), where \( p_i \) is one of his preferred styles in learning, e.g., like to study together with other learners, like to work through concrete experiences, etc. Every learning method for a UOL stored in the UOL database has a similar set \( M = \{ m_1, m_2, \ldots, m_m \} \) describing its traits, where \( m_k \) is a style it can accommodate. The agent recognizes if a method is suitable for a learner by comparing set \( M \) and \( P \). The fit degree is calculated by summing the numbers where the learner's favoured styles are met by a method, namely \( V_{fit} = \sum (p_i \text{ in } M) \). A method is recognized as an appropriate one for a learner if its \( V_{fit} \) is larger than a designated threshold value. A method is considered as the optimal one if it has a larger \( V_{fit} \) than others.

3.2 Guiding Learners to Dynamically Revise Learning Plans

Guiding learners to align learning towards their goals is implemented through managing individual learning plans. The agents perform the work with the aids of the two lists, activity list and check list. Every learner is associated with those two lists so that the progress of his learning plans can be managed. While a learner starts to learn a UOL, the UOL, its learning goal (i.e. the goal UOL), and the adopted learning plan for achieving the goal are together put into his activity list. While he has completed the learning for a UOL, the UOL will be put into his check list. The two lists are dynamically updated and maintained by the agents.

The requirements for aligning learning recognized by the agents take place mainly in two scenarios: 1) while a learner starts to learn a new UOL but he has not completed all the UOLs planned to learn prior to the
one he is going to study. The agent first captures the learning plan the learner is adopting for the goal UOL from his activity list. It then compares the check list for him against the learning tasks scheduled in the plan to see if the check list contains all the UOLs planned to learn prior to the one he is going to study. If it does not, the agent will suggest him to adjust learning. 2) while he is not able to achieve the objectives of the UOL he is learning under the conditions at that time. An obvious case is he has failed to submit the desired artifact files for a long time after he started learning the UOL. Another case is the evaluation to his submission of the artifact files indicates that he has not achieved the objectives of the UOL.

In general, the agent makes suggestions for two kinds of adjustments: 1) to keep the learning plans being carried out unchanged and select another UOL to learn; or 2) to revise one of the plans being carried out. The agent generates a suggestion for the first kind of adjustments through examining the current plan and the check list for the learner. It can identify what should be learned next by comparing the learning tasks planned in the current plan against the ones in the check list. It is a challenging task to generate a suggestion for the second kind of adjustments as it needs a complicated search procedure. Because a UOL with a larger grain, e.g. a subject, a chapter, etc. may have a lot of learning paths, constructing a considerable complicated hierarchical architecture, there are very complicated relationships between the plans which are being carried out and the ones which can be adopted after some adjust. To search a suitable plan in the hierarchical architecture, the agent has to examine the plans from the current UOL to higher level UOLs level by level. That is, the agent first checks if there is any possible plan to reach the current UOL’s goal, and if not, it will further check if there is any possible plan suitable for the goal of the higher level UOLs. In this way the agent checks the plans for the UOLs level by level until it finds a suitable plan or attains another reasonable result.

4. SUMMARY

The paper described the online learning process and presented an agent-based way to support online learning through assisting learners to dynamically adjust learning processes. It described the agent implementation methods for guiding learners to develop personalized preferred learning plans and dynamically adjust learning.

ACKNOWLEDGEMENT

The author would like to thank Professor Igor Hawryszkiewycz for his supervision and valuable input to this paper.

REFERENCES


Koper, R. Modeling units of study from a pedagogical perspective: the pedagogical model behind EML. Available at: http://eml.ou.nl (10/12/2004)


