FACILITATING CONSTRUCTIVIST LEARNING THROUGH MANAGING LEARNING PROCESSES

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

ABSTRACT
Nowadays online learning has been recognized as an important alternative to conventional classroom learning. However many current online instructional systems merely supply course materials for learners without providing effective services to support learners to construct knowledge. Learners only *passively* receive information from the presented materials. They have not been engaged in *actively* constructing meaningful understandings of the study theme by using a constructivist method. This work tries, through managing learners' learning processes, to *actively* assist them to construct knowledge in a constructivist way. In this paper, the online learning process is structured and the services to support knowledge construction in the process are defined. The database for providing information to implement the services is exploited, including a specification language to describe the learning activities, the major components and their roles to supply the services. The approaches to implementing these services are respectively studied.

KEY WORDS online learning, learning processes, management of learning processes, learning plans, knowledge construction, constructivist methods of learning, constructivist learning environments

1. Introduction

With the rapid technological and social change, there is a growing need for lifelong learning. Online learning is increasingly being used to satisfy such a need. It has been widely recognized that online learning has many attracting features, such as enabling more learners to have access to the learning resources and providing learners and teachers with unprecedented flexibility and convenience [1]. Online learning is thus rapidly gaining momentum. On the other hand, however, most current online instructional systems just simply deliver course materials without integrating the role of guiding learners to use these materials to construct knowledge. In such courses, learners are directly told about a solution for the problem being studied or are taught how to get the solution using a designated mode. As the results, learners only passively receive the information from the presented materials. They have not been engaged in independently exploring possibilities and inventing their own solutions in the process. According to constructivist perspectives for learning, knowledge cannot be transmitted to learners but must be constructed by learners [2]. Thus, research is needed to develop ways to engage learners in *active* knowledge construction, rather than passively receiving information from the materials. These must include services that go beyond simply presenting online materials, but provide a wider range of technological facilities, tools and services to support the learning process.

Because constructivist theories for learning emphasize the environments where learners learn [3], many researchers have been drawing attentions on designing and developing constructivist learning environments (CLEs) to facilitate knowledge construction. Duffy and Cunningham for example have proposed seven design goals of a CLE [4], i.e. 1) all knowledge is constructed and all learning is a process of construction; 2) multiple perspectives of reality world can be constructed; 3) knowledge is context dependent; 4) learning is mediated by tools and signs; 5) learning is an inherently social-dialogical activity; 6) learners are distributed, multidimensional participants in socio-cultural processes; and 7) knowing how we know is the ultimate human accomplishment. Lefoe, based on these goals, has carried out work on their development of a CLE [5]. Wilson and colleagues have outlined three core principles for effective learning on CLEs [6]: 1) provide access to rich sources of information; 2) encourage meaningful interaction with content; and 3) bring people together challenge, support, or respond to each other. Kunz has moved further to the components of CLEs and outlined the necessary various components [7]. Obviously these earlier work have provided significant guides for designing environments to facilitate online learning. There still require further research and development to apply them to implement a CLE.

Our work is to develop such a kind of CLE that provides *active* services for individual learners to facilitate effective learning experiences in the environment. This paper is focused on providing services to assist learners to develop personalized learning plans and conduct learning activities and guide them to align learning towards their objectives. These services are implemented major through managing their learning processes.

The paper is organized as follows. In the next section an online learning process will be structured and modelled and then the services to support knowledge construction will be defined. In section 3 the database providing information for implementing the services will be investigated, including a specification language to describe

the learning activities in online environments, the major components of the database and their roles to providing the services. In section 4 the approaches to implementing these services will be respectively explored and the involved implementation techniques will be conceptually described. Finally in section 5, the preliminary result and the outlook of the research will be presented.

2. The model of an online learning process and the services to support knowledge construction

2.1 A brief review of the research on the models of an online learning process

To use technological means to assist online learners to construct knowledge more creatively requires ways to integrate technology into a learning process in non-obtrusive ways. To do this the online learning process must be clearly defined in terms of learning activities. Considerable research efforts have taken place to structure and model the online learning process. For instance, Laurillard has approached this issue from the viewpoint of learner learning [8]. She argues that there are four main activities in the process, i.e. *discussion*, *interaction*, *adaptation*, and *reflection*. Bybee has investigated this issue from constructivist perspectives for learning and claims that learning is not a linear process [9]. In his 5E model the process is explained by *engagement*, *exploration*, *explanation*, *extension*, and *evaluation*. Salmon has identified five stages in her model for the online learning process, i.e. *access and motivation*, *online socialization*, *information exchange*, *knowledge construction*, and *construction* [10].

Most of such investigations have generated profound implications on this issue. However, they are very general and mostly concentrated on a theoretical level, and cannot really specify how to achieve the various activities in the model and how to support these activities in the process. Online learning possesses many particular features, totally different with traditional classroom learning, e.g. learners are physically separated and have varied profiles, many Internet-based technologies can effectively enhance learning, a huge number of resources available over the Internet can benefit online learning, etc. Most importantly, online learners take on a much more role than learners in other learning environments. Therefore a further research is needed to develop a model to exhibit theses features and provide more clues for how to support knowledge construction in the learning process.

2.2 A model for describing an online learning process

According to constructivist perspectives for learning, we take the online learning process as a learner's self-regulation process of building ideas and concepts through reflection, abstraction and interaction with the learning environment. The centre of learning is placed on concept development and understanding through appropriate activities. A prime emphasis here is the self-adjustment organized by the learner while the learning is proceeding. The learning plan, which includes the learning activities to be taken and the conduct sequence, is taken as a core of the self-adjustment. A learning process can be described in terms of the progress of a learning plan, e.g. its building, carrying out, managing, etc.

We use the model shown in Figure 1 to describe an online learning process. Online learning is initiated and driven by a learning goal. After a goal is constituted based on a problem, a project or a case under study, a learner experiences a learning process to reach it. The first step of the process is to *build a plan* to achieve the goal. This includes defining the learning activities to be taken and designing the method to conduct these activities according to his particular cognitive characteristics and learning history. Then, the learner *carries out the plan* to construct knowledge in a domain. He takes the learning steps in the sequence as defined in the plan. These learning steps are various learning activities e.g. accessing learning resources, discussing with other, doing assignments, doing self-assessments, requesting assistance from others, etc. While the learning is progressing, the learner *manages the plan* to timely align learning towards his goal. This includes recording the learning activities, evaluating their outcomes, and then revising the current plan accordingly. The updated plan will immediately affect the learning process; the relevant activities or sequences will be revised. The learning based on the updated plan will be evaluated again and then will 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.

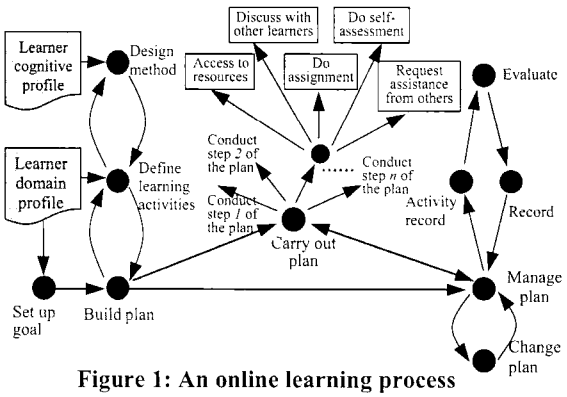

Figure 1: An online learning process

2.3 The services to support knowledge construction in an online learning process

The model of an online learning process shown in Figure 1 reveals some clues for how to use technological means to assist a learner to construct knowledge in online learning. Broadly the services at least include: 1) providing access to appropriate learning materials that meet his learning requirements and match his particular learning styles; 2)

fostering him to interact with content, fellow learners and teachers; 3) encouraging and supporting him to actively participate in collaborative work; and 4) assisting him to timely and accurately evaluate learning achievements [11]

Figure 2 shows some examples of the services we are developing for supporting learners to construct knowledge in the online learning process. While a learner builds a plan to achieve a learning goal, he will be advised of suitable learning plans to achieve the goal according to his learning characteristics. He can select to follow one of them, or make his own plan for the goal. While he carries out the plan, he will be offered with a wide range of services for assisting him to conduct relevant learning activities. These include suggesting learning resources for a particular study theme, suggesting discussion forums for him to participate in discussions on the theme, suggesting suitable assessment methods for him to do self-assessment, suggesting people for him to get assistance, etc. Meanwhile the learning activities he is conducting are monitored, the learning outcomes are evaluated, and suggestions for plan adjustment will be given to him whenever needed.

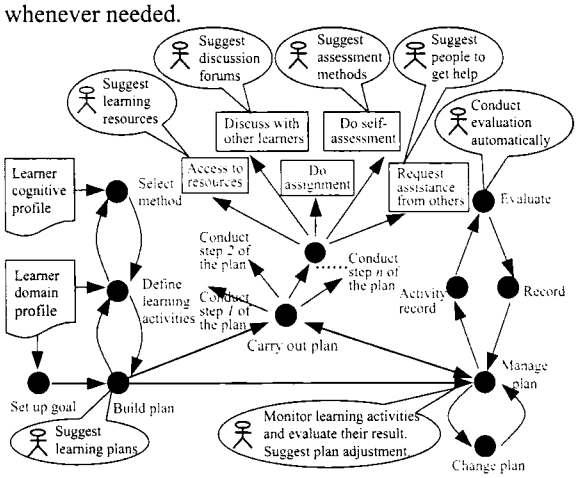

Figure 2: Services to support knowledge construction

All these services are not compulsory, and the learners are free to accept the ones if they need. The purpose of these services is to engage learners in knowledge construction and promote its success through providing guidance for learners to solve the problems which probably emerge in learning processes.

3. The UOL database for implementing the services

3.1 The specification language for describing online learning activities

Quite clearly, in order to make such services be adapted to a learner's *just-in-time* needs in online learning, knowledge about the learning activities being conducted by the learner and the practical progress of the learning process is necessary. It thus requires a database to provide such knowledge. The first foundation work to develop the database is to develop a specification language to describe online learning activities.

Such a specification language has been concerned by many researchers for different purposes. Some are for the sharing and reusing of learning resources, i.e. *learning objects*. Several standards, e.g. the IEEE LTSC/IMS standards, Dublin Core Metadata Initiative, SCORM's Content Aggregation Model, CISCO's Reusable Learning Object strategy, etc., have been proposed to describe learning objects. They define standard elements to describe various learning objects so that they can be shared in online instructional systems. Although they have developed ways to dynamically assemble learning materials, they deliver a same content to all learners.

Recent progress in this area is the research into sharing and reusing learning designs. They try to use standard ways to describe learning designs so that they can be shared and reused. The first version of the IMS Learning Design specification (IMS-LD) [12] is a typical example of these researches. It can describe a wide range of online learning activities by a language built on the Educational Modelling Language (EML) [13]. The core of the EML is a description of how the teaching and learning is conducted in an environment with resources [14]. Because IMS-LD attempts to develop a generic language to describe and encapsulate a wide range of learning activities, it has become very complex due to the diversity of learning methods. Moreover it seems unsuitable to select one from the encapsulated templates of learning methods and then impose it to an individual learner because the impose method is most likely not the optimal one for him. According to the constructivist views, online instructional systems should assist and scaffold learners to learn, rather than imposing a particular learning method to them.

Our purpose is to develop a way to describe learning activities so that knowledge construction can be supported and facilitated by the services supplied by the system. Building upon the earlier work in this area, particular the EML, we are developing a specification language to describe and specify learning processes for constructivist learning. The primary means is to adapt and extend the object parameters of the EML in ways that they can be flexibly combined to describe the arrangements of learning activities and the relevant services to support personalized learning and constructivist learning.

Our specification language describes a unit of learning (UOL) that satisfies one or more learning objectives. A UOL may correspond to a course or a subject, a module, a lesson, or even a single learning activity such as a discussion to elaborate on some topic. It is the major source of the information needed for implementing the services to support constructivist learning.

3.2 The components of a UOL and the roles for implementing the services

As shown in Figure 3, a UOL described by our specification language is composed of seven elemental objects, i.e. *metadata*, *roles*, *content*, *methods*, *assessments*, *case studies* and *learning plans*. Each of them contains more elementary objects, constructing a complex structure [15]. The major components and their roles for implementing the services to support knowledge construction are analysed as below.

The *roles* field in a UOL specifies the intended users of the UOL. Its *property* field contains the description of the learning characteristics of every class of the intended learners. This makes it possible for the online instructional system to provide services based on the category of the learners. The services that can be dynamically adapted to suit individual learning characteristics will maximise learners' learning potential.

The *content* field contains the description for all the learning resources and all the learning activities, i.e. the ways to use the learning resources to achieve a learning goal. This enables the system to provide supportive services not only related to learning resources but also related to learning methods in online learning.

The *activity structure* field describes all the possible methods suitable for a particular category of learners to achieve the learning objectives defined in the UOL. Within an *activity structure* there are multiple *activity sequences* each of which provides a particular method to conducting the learning activities for the learning goals. This enables the system to provide a learner with learning

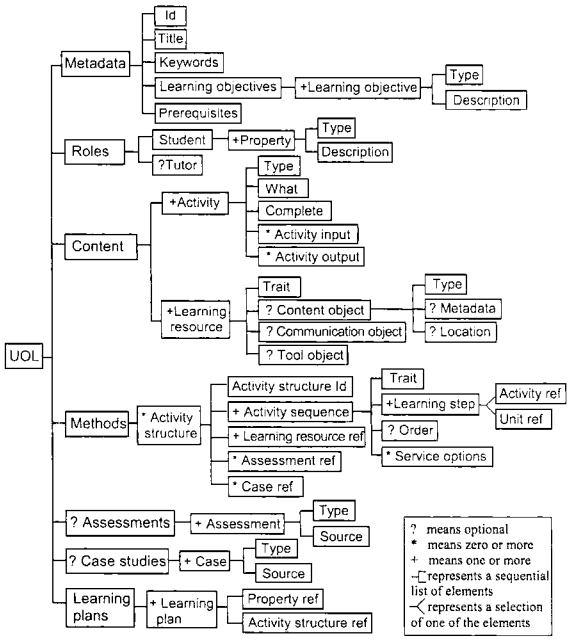

Figure 3: The architecture of a UOL

methods that suit his learning characteristics. It also enables the system to assist him through multiple methods. The latter is consistent with the principle of the constructivist learning, i.e. learners may construct their own understandings to a theme in different paths.

For a particular *activity sequence*, more than one learning resource can be referred. This makes it possible to advise a learner of multiple suitable learning resources while he conducts learning. He can hence select the optimal one from them according to his *just-in-time* needs.

The *activity* field describes a learning activity for the unit. Its *complete* field specifies a progress status of the learning while the activity is completed. This makes it possible to monitor the completion of a learning activity. Its *activity output* field specifies the artefact files for evaluating the outcomes of learning. In addition, multiple assessment items are allowed to be referred for a particular *activity sequence*. Thus, the outcomes of learning can be evaluated as the learning is proceeding, and hence the possible problems in learning can be identified immediately and the related remedy to the learning can be made in timely ways.

An *activity sequence* can be associated with multiple optional case study materials. This enables the system to supply a learner, through more than one case study material, with guidance to conduct learning for a unit, which will effectively scaffold knowledge construction.

The *learning plans* field provides the links between a learning method and its targeted learner category. This enables the system to specify the learning methods based on the type of the learner.

4. The implementation of the services

4.1 Suggesting learning plans

While a learner builds a plan for achieving his learning goals, he will be advised of several plans which he can adopt to achieve his goals. These are the methods of conducting learning for his goals, extracted from the UOL database based on his learning styles. With such an offer, the learner can easily build his learning plan for his goals by selecting one from them or adapting them according to his own particular requirements. The implementation process is shown in Figure 4. A unit is first determined by matching the learner's learning goals to the objectives of a unit in the UOL database. Then the learning methods for the unit in the database are extracted and the ones that suit the learner are further identified according to the fit degree of a method for the learner. These selected methods, i.e. the arrangements of related learning activities and the conduct sequences, are presented to the learner as the recommended plans for him to achieve his goals.
The following technique is used to recognize if a learning method is suitable for a learner and to measure the fit degree. The learning property of a learner, stored in his

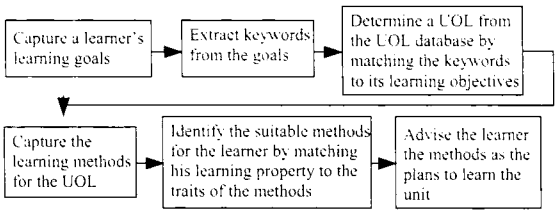

Figure 4: Suggesting learning plans

cognitive profile, is characterised by a set of his preferred styles in learning, e.g. like to work together with others, like to work through concrete experiences, like to work with visualising images, etc. All the learning methods stored in the UOL database use a similar way to describe each one's traits. If a learning method can meet a particular style, then the style will be put into the *traits* filed for the method. Comparing a learner's preferences against the *traits* filed of a method can identify if the method is suitable for the learner. The fit degree can be further measured by summing how many the learner's favoured styles are met by a method. A learning method is considered as the optimal one for a learner if its fit degree is larger than other learning methods.

4.2 Advising appropriate learning resources

Providing the service to assist a learner in selecting appropriate learning resources to conduct learning has particular relevance to online learning since it is based on the particular requirement of some online learners. Early studies have found that some learners may lack of necessary *prior* knowledge or abilities to independently choose a learning resource to conduct learning [16]. This probably constructs an obstacle that hinders them continuing the learning process. Therefore services are necessary to assist them to overcome the challenge.

What degree of the assistance is suitable for helping a learner to choose learning resources? Clearly it is inappropriate for constructivist learning if the system *appoints* one to him, just as the instructivist mode used in a traditional classroom. This is because in that case he will be imposed to a learning resource and most likely, the imposed one does not suit him. We have moved away from this mode and adopted a flexible strategy to provide the assistance. The learner is not imposed to any learning resource; instead he is advised of several suitable resources to let him choose based on his own particular requirements. In this way the autonomy of the learner in learning has been supported. Meanwhile he is offered with the suggestion for selecting learning resources. Thus, he can select one from what is being offered by the system if he has troubles with independently making decisions.

The implementation of the service is major on the identification of the learner's dynamical learning needs and the comprehensive understandings of his learning styles and experiences. As described in the previous section, the description of the learning methods stored at an *activity structure* field in the UOL database contain the references of the learning resources for every learning sequence. Accordingly the learning resources can be easily extracted from the learning methods, after they are determined based on the learning goals and learning styles of the learner. Furthermore, the suitable ones can be identified by matching his learning characteristics to the traits of the learning resources, stored in the *content* filed in the UOL database.

It is worth mentioning here that the implementation approach to suggesting assessment methods, suggesting discussion forums, or suggesting people to get help is similar to the one described here. Also the critical work relies in the identification of the individual learning needs and the understanding of individual styles and experiences. The extra work for suggesting discussion forums or people to get help includes monitoring the learning environment and mining valuable information from it. For instance, the implementation for suggesting discussion forums for a learner requires monitoring all the discussion forums in the learning environment and identifying each one's topic and participants so that the suitable ones can be identified and forwarded to the learner accordingly.

4.3 Monitoring and evaluating the progress of learning

The evaluation to a learner's learning mainly includes: 1) Monitoring the self-assessment being conducted by the learner for a unit and evaluating its result. It is considered that the learner has successfully completed the learning for a unit if he conducts the self-assessment with a correct rate which is larger than a value, e.g. 70%; and 2) Monitoring the learning activities being conducted by the learner and evaluating his submission of the related artefact files. The evaluation of the learning for a unit is implemented through comparing a learner's submission of the artefact files against the artefact files specified at the *activity output* field in the UOL database. If all the desired outcomes have been embodied in the submitted artefact files, the learning for the unit is considered as successfully completed. The learning activity a learner has successfully completed will be put into *check list* for the learner, which serves as a vehicle for managing learning processes.

4.4 Suggesting adjustments of the learning process

Suggesting a learner to adjust learning towards his goal is an important service to facilitate effective learning experiences in online environments. It can effective guide a learner to conduct learning in an optimal path to his goal. The implementation of this service is based on the management of individual learning plans. While the evaluation to a learner's learning shows that he is not likely to successfully complete a learning activity at that time, the learner will be suggested to adjust the learning process, e.g. to take another learning activity first. In addition, while a learner starts a learning activity, the

learning plan he is carrying out will be examined and if the *check list* for him does not contain all the activities planned to be taken *prior* to the one he is going to take, he will be suggested to adjust the learning process by either revising the current plan or doing another activity first.

As to the suggestion content, it is not enough for some learners if it merely contains a prompt suggesting learning adjustment. It is a challenging task to offer an advice on how to align learning because there are considerable complicated relationships between the plans that are being carried out and the ones that can be adopted, and the ones that can be adopted after some adjust.

Two kinds of learning adjustment are possible: 1) keep the learning plans being carried out unchanged and select another unit to learn; or 2) revise one of the learning plans being carried out. It is easier to generate a suggestion for the first kind adjustment because the unit suitable for learning at that time can be identified by comparing the learning activities defined in the learning plans and the ones included in the check list for him. However it requires a complicated procedure to generate a suggestion for the second kind adjustment. In general, it needs to check if there is any other learning plan suitable for the learner to learn the unit. If not, it needs to further examine if there is any other plan for the unit's goal unit. This procedure is repeated until a suitable plan is found or a reasonable result is attained.

5. The research perspectives

The work presented in this paper is a part of our research on *facilitating constructivist e-learning by software agent technologies* [11], which is currently in progress. This paper has been focused on the online learning process model, the supportive services for knowledge construction, the UOL database and the implementation approaches to providing these services.

Our preliminary research and experiment have shown that online learners can be provided with services to support knowledge construction through the management of their learning processes. The services outlined above, e.g. suggesting learning plans, advising appropriate learning resources, evaluating learning progress, suggesting adjustments of learning based on its practical progress, etc., can engage online learners in actively knowledge construction and promote more creative learning. The crux to providing these services relies in the recognition of the learners' dynamical learning requirements and the comprehensive understandings of their learning styles and experiences. In the next, we will be extending the UOL database and refining the implementation of the supportive services so that online learning will be effectively and efficiently promoted by such services.

References

[1] Shen, R., Han, P., Yang, F., Yang, Q. & Huang, Z. An Open Framework for Smart and Personalized Distance Learning. *1st International Conference on Advances in Web-Based Learning*, Hong Kong, China. pp. 19-30, 2002.

[2] Jonassen, D. Designing Constructivist Learning Environments. In C. M. Reigeluth (Eds), *Instructional Design Theories and Models: a New Paradigm of Instructional Theory*. MahWah: Lawrence Erlbaum Associates, Publishers. Vol. II, pp. 215-240, 1999.

[3] Jonassen, D. Think Technology: Towards a constructivist design model. *Educational Technology, 34*(4). pp. 34-37, 1994.

[4] Duffy, T. M. & Cunningham, D. J. Constructivism: Implications for the design and delivery of instruction. In D. Jonassen (Eds), *Handbook of Research for Educational Communications and Technology*, NY: Macmillan Library, USA, 1996.

[5] Lefoe, G. Create Constructivist Learning Environments on the Web: the Challenge in Higher Education. *ASCILITE'98 Conference*. pp. 453-464, 1998.

[6] Wilson, B. G., Teslow, J. & Osman-Jourchoux, R. The impact of constructivism (and postmodernism) on instructional design fundamentals. In B. B. Seels (Eds), *Instructional Design fundamentals: A review and reconsideration*. Englewood Cliffs, NJ: Educational Technology Publications, 1995.

[7] Kunz, P. The Next Generation of Learning Management System (LMS): Requirements from a Constructivist Perspective. *ED-MEDIA 2004*, Lugano, Switzerland, June 21-26. pp. 300-306, 2004.

[8] Laurillard, D. M. Multimedia and the changing experience of the learner. In Ryan, M. (Eds), *Asia Pacific Information Technology in Training and Education Conference*, Vol. 1. APITITE 94 Council, Brisbane, Australia, pp. 19-24, 1994.

[9] Bybee, R. Constructivism and the Five E's. http://www.miamisci.org/ph/lpintro5e.html (15/02/2004).

[10] Salmon, G. *E-moderating: The key to teaching and learning online*. London: Kogan Page, 2000.

[11] Pan, W. & Hawryszkiewycz, I. To Develop Constructivist Learning Environments on the Web Using Software Agent Technology. *IASTED International Conference on Computer and Advanced Technology in Education*, Hawaii, USA, August 16-18. pp. 236-241, 2004.

[12] IMS. IMS Learning Design Specification V1.0. http://www.imsglobal.org/learningdesign/index. cfm (10/04/2004)

[13] Koper, R. *Modeling units of study from a pedagogical perspective: the pedagogical model behind EML*. http://eml.ou.nl (10/07/2004)

[14] Koper, R. & Manderveld, J. *Educational Modelling Language: modelling reusable, interoperable, rich and personalised units of learning*. http://www-jime.open.ac.uk/2004/6/koper-2004-6-disc-12.html (10/07/2004)

[15] Pan, W. & Hawryszkiewycz, I. A method of defining learning processes. In R. Atkinson, C. McBeath, D. Jonas-Dwyer & R. Phillips (Eds), Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference. Perth, December 5-8. pp. 734-742, 2004.

[16] Large, A. Hypertext instructional programs and learner control: A research review. *Education for Information*, 14. pp. 95-105, 1996.