Knowledge Construction in e-Learning: designing an e-Learning environment

Lily Sun, Shirley Williams and Kecheng Liu

Department of Computer Science, The University of Reading, UK
Email: {lily.sun, shirley.williams, k.liu}@reading.ac.uk

Abstract: In the traditional classroom, students learned to depend on tutors for their motivation, direction, goal setting, progress monitoring, self-assessment, and achievement. A fundamental limitation is that students have little opportunity to conduct and manage their learning activities which are important for knowledge construction. e-Learning approaches and applications which are supported by pervasive technologies, have brought in great benefits to the whole society, meanwhile it also has raised many challenging questions. One of the issues that researchers and educators are fully aware is that technologies cannot drive a courseware design for e-Learning. An effective and quality learning requires an employment of appropriate learning theory and paradigms, organisation of contents, as well as methods and techniques of delivery. This paper will introduce our research work in design an e-Learning environment with emphases on instructional design of courseware for e-learning.

1. Introduction

An e-Learning approach has played a pivotal role in improving flexibility and quality of education and training by using the Internet and collaborative technologies (Schweizer 1999, Takacs *et al*. 1999, Gottfredson 2002). A number of specific applications, such as IBM Lutos LearningSpace, Blackboard, Microsoft Visual Studio, and Netware have been employed to support teaching and learning at universities. Evidence (Anderson 1998, Beller and Or 1998, Shank *el at*. 1994, El-Tigi and Branch 1997, Horton and Horton, 2002) show that these applications enable individual tutors to put teaching materials online, create discussion forums, organise assessments, and link with other sources. To a limited extent, these applications can support course design, but it is often up to the individual tutors to decide how the teaching materials should be organised. Researchers and educators are fully aware that technologies alone will not generate much benefit and are not the drive for courseware design. The most important aspects in e-learning are the employment of appropriate learning theory and paradigms, organisation of contents online, as well as methods and techniques

of delivery. So far there is little research for a development of suitable methods for online courseware design with the teaching and learning rooted in a sound educational theory embedded.

With this understanding, we base our work on the theories of constructivist and semiotics. These two theories encourage students to take responsibilities for the learning process. To acquire capability of deep learning, critical analysis and self-reflection is seen as more important and profund than acquring knowledge. Deep learning can only be realised by totally engaging the learners in knowledge construction as opposed to knowledge transfer. Constructivisit and semiotics guide us in devising a model for an e-learning environment and instructional design principles for courseware in this environment.

In this paper, we will first of all, critically assess the current practice of teaching and learning supported by technologies. Constructivist theory and semiotics are discussed in light of their relevance to e-learning. Components of a model for instructional design of courseware for e-learning are described based on our early work, followed by discussions on the current work and future research.

2. Critical Assessment of Current e-Learning

A body of knowledge with examplar practice shows promising results and a great potential in e-learning (Cunningham 1987, Uden and Liu 2001, Liu and Sun 2002, Jona 2000, and Martinez, 2002). However, a large propotion of e-learning tends to be limited by only making contents available online together with assignments to set learning milestones. The online contents are normally orgainsed according to the functions encoded in the e-learning software. As a result, association between related contents and materials is not based on the ground of effective learning, but more due to the technical constraints or availabiliity of the software. The design of the courseware for e-learning is often driven by the technologies. The observation below summarises the issues, which require attention in future instructional design for e-learning.

- Learning is still pre-determined by instructional sequences and in a *push* manner. Students, therefore, are constrained to apply their prior knowledge to generate their mental models and to conceptualise various parts of information to form a whole within a given context.
- Students often find themselves in various situation and carry out multiple learning activities, which are hardly supported by the current course structure.
- Most computer assisted learning provides with customisation and personalisation machenisms, but little methodological guidance is provided for instructors to introduce the functions of the *social negotiation* on individual learning goals, learning content and learning methods into the courseware.

All these are due to the contents have been simply made eclectronically available. They are not organised in a manner for self-analysis and student-centred learning, and are also not presented to encourage students to seek knowledge independently and achieve their learning goals. There is

therefore a need for a conceptual model underpinning the courseware for e-learning which is firmly rooted in a sound theoretical framework and teaching & learning paradigm. In this project, we proposal an e-learning environment which enables students to construct knowledge and engage deep learning in a self-motivated and driected manner.

3. Learning as Knowledge Construction

It is recognised in the education that learning is a process of knowledge construction. Constructivist claims that learners construct their own reality, or at least interpret it based upon their perceptions or experiences. According to constructivist (e.g. Savery & Duffy 1994, Honebein *et al.* 1993), knowledge is in our interactions with the environment. Learning is motivated by cognitive conflicts or puzzlements, which influences the organisation and nature of what is learned. Understanding is affected through the social negotiation of meaning. As the learner is the focus of the enterprise, they should be protected from potentially damaging instructional practices by promoting personal autonomy and control of learning. Support towards self-regulation should be provided by promoting the development of skills and attitudes that enable learners to take on increasing responsibility for their learning. Intentional learning and examination of errors should always be encouraged. Constructivists emphasise the role of the learners, who initiate the learning. The learners act and interact within the flux of events and actions. Through these acts they build their world and construct their knowledge.

Semiotics, as a discipline of the study of sign, has a strong influence on the way we understand the world which we live in and the way we conduct our work. The subjects of study of semiotics are all kind of signs. A sign is "something which stands for something else in some respect or capacity" (Peirce 1931-35). Signs can be a verbal language, pictures, literature, motion pictures, theatre, body language, and more. Semiotics has a strong relationship with understanding, as Peirce described in the key notion: semiosis (Figure 1). Semiosis is a

process that involves an agent using a sign in understanding or interpreting something (Liu 2000). Understanding is a subjective process where the prior knowledge affects the interpretation of a given sign, and vice versa. It is difficult to assume for all agents involved to derive the same association between a given object and a sign, as it involves issues such as meaning, cognition, behaviour, culture and social

concept HOUSE

INTERPRETANT/NORM
THIRDNESS

I

S   O

FIRSTNESS
SIGN

SECONDNESS
OBJECT/REFERENT

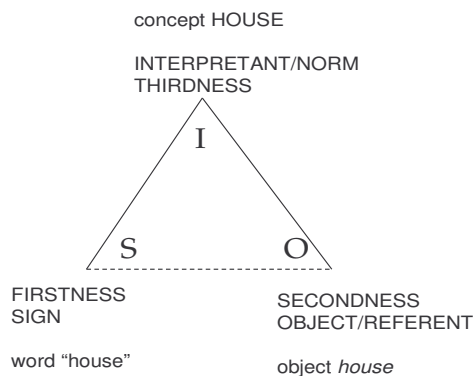word "house"   object *house*

Figure 1. Semiosis as a process of understanding.

context. The learner, i.e. the agent, is in the centre of the semiosis process and has a control over it. Learning and understanding in this paradigm can be only realised by creation and use of signs.

Understanding the process of knowledge construction based on these two theories enables us to identify some important features of learning (Liu and Sun 2002, Uden *et al.* 2001).

1. Learning is a process of knowledge construction, rather than knowledge transfer or injection. Within semiotics the process of semiosis is deemed as a knowledge construction process whereby what we experience as reality is really prior cultural and personal codings - knowledge is not an entity to be acquired but a process of how we come to know. Within the constructivist realm, knowledge is constructed through interaction with the environment.

2. Learning is subjective. There is no single objective reality, knowledge construction is a process of personal interpretation of the perceived world and the negotiation of meaning. The process of semiosis enables us to

structure our experiences and reveal the nature and culture of our understanding. Constructivism advocates that there are no cause-effect relationships between the world and the learner; learning to a large extent depends on the subjective view of the learner.

3. Learning should be collaborative - learning is negotiated from multiple perspectives. Semiotics promotes educational strategies that emphasise many sign systems, or many ways of knowing. Constructivism emphasises that learning emerges from the human organism in ways which conserve adaptation and organisation - learning is to apply some sort of conceptual system upon the phenomena and to bring forth a world including those phenomena.

4. Learning is situated, and it should occur in realistic settings. Signs as codes of experience, according to semiotics, are related to social settings where learning takes place; learning is never a private act. The constructivist approach notes that living systems survive by fitting with one another and with other aspects of the surrounding medium.

These features can be incorporated in e-learning during the courseware design for e-learning.

4. Impact on e-Learning

Knowledge, in semiotics, does not consist of objects or entities that we "acquire", but is better thought of as knowing, or a process. We build ways of knowing – abilities of understanding and interpreting, which is seen as an affordance. Gibson (1979) uses this term to describe biological patterns of behaviour. Stamper (1985) extends this further to denote social patterns of behaviour from the perspective of an organisational semiotics. The affordance acquired by a learner maps on to the process of knowledge construction which displays structures that determine his current understanding through his experience in the world. Through these structures, one literally constructs ones knowledge dynamically as one interacts in the world. Knowledge is not "out there" waiting to be discovered. The world as we know is culturally coded, relying on prior structures invented (not discovered) both

collectively by our culture and individually by us. The refusal to accept the separation of knowledge from the knower is exactly what both constructivist and semiotics believe. An effective learning can only be realised through a highly interactive process in which the learner is totally engaged.

Another concept which is very relevant to learning from the theory of semiotics is that of *intertextuality*. It is argued that the meaning of a given text cannot be ascertained within that text itself, but only in relation to a broad spectrum of other texts or even social and culture context. This implies that all our knowledge is essentially intertextual, always embedded within a system of prior social and cultural codings and future possible codings. The concept of intertextuality has been most influential in theories of reading and writing. Meaning in reading is created by readers as they interact with the text. Texts only exist in reaction to what readers produce. Semioticians believe that the basic state of human consciousness is a state of belief. Beliefs can change through Abduction. Abduction is the inferential move where we, when confronted with some experience not accounted for by our existing beliefs, invent a new set of beliefs or revise an existing one. This new structure will provide a context within which the surprising experience is a matter of course (i.e., it makes sense). Teaching methods that promote abduction should be encouraged.

Semiotics theory also offers promise as a tool for understanding education as a social and cultural process. Inherent in semiotics is the notion of reflexivity, a reflection on our reflections, thinking about our thinking process, or knowing how we know. According to Cunningham (1987), "To be aware constantly of the assumptions guiding particular theory and method is to be free to examine alternatives, to invent different interpretative contexts and explore their consequences." The implications for learning and thinking are enormous. For one thing, knowledge would now be regarded as a process, not a static structure to be learned and remembered. There would be more

emphasis put on how to think rather than what to think. Curriculum would be more interrelated. Teachers would become models of semiosis and monitors of the student's ongoing semiosis. Educational establishments would become places where appropriate contexts for knowledge are provided.

Adopting semiotics and constructivist paradigm would have a tremendous impact on designing of an e-learning environment. An e-learning environment should facilitate learners to interpret the multiple perspectives of domain context, guide learners to conduct and manage their personalised learning activities, and encourage collaborative and cooperative learning for critical thinking and problem-solving. A course should be designed in such way that participants can be facilitated and guided for their learning activities and empowered to mediate and control their knowledge construction to achieve their learning goals. The collaborative learning environment will also offer other benefits. For example, there are quality teaching materials widely available from the internal source and the Internet. They can be selected and used as main teaching materials and auxiliaries, but there is no mechanism for sharing and reuse these materials. There is demand for reusing course contents and public available materials for tailoring course to meeting different target audience. This will save much time and cost to develop courses serving multi-disciplinary degree and training purposes. Knowledge transfer without constraints of geographic location and time difference is another area where the collaborative learning environment can help. It is possible to quickly package a course by using the sharable elements of the teaching materials in the repository.

5. A design of an e-Learning Environment

Based on the above principles, an e-learning environment has been designed for authoring and delivering modules for a university's degree course (Bachelor and Master level) (Figure 2). In this environment, students normally participate in learning as a personal and social construction of knowledge, and development of critical-thinking and

problem-solving skills. A number of components have been defined that consist of the guidelines and templates:

independent learning, communication, presentation, writing, and team working, can be defined and embedded in the subject inquiries.
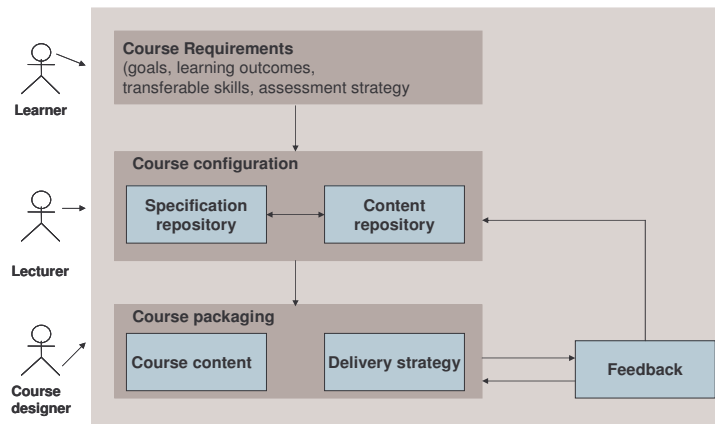

Figure 2. A methodology for instructional design of courseware and contents in e-learning.

1. *Course requirements*. This component enables an instructor to set an academic scope about a course that is derived to meet the needs of target learners. Requirements related to a course are categorised:

- **Learning goals** describe what subject knowledge students are expected to acquire and apply to situations. Learners can then set their learning activities to construct knowledge and develop skills.

- **Learning outcomes** specify expectations from the instructor and learners perspectives. The learning goals will be assessed by measuring the learning outcomes which should reflect the standards set by the academic institutes. The learning outcomes are described using quantifiable words/ontology so that learners follow them to plan their learning activities. The ontology (i.e., a conceptual map) is related to content objects and it can therefore assists the content selection.The learning outcomes should encourage students to develop the learning method on critical thinking, problem-solving, and decision-making for judging findings.

- **Transferable skills** are important for students to have for knowledge construction, extension, and self-reflective practices. These skills, e.g.,

- **Assessment strategy** defines a suitable method of assessing learning outcomes to meet the learning expectations, e.g., replication, understanding and application of knowledge and skills. An assessment strategy is subject-dependent. Various assessment methods are available for choice, e.g., multiple choice test, continued assessment, examination, and coursework. A difficulty with some of these methods (e.g., continued assessment) is that the assessment content is not certain at the beginning of the course. It should in principle be developed and built as the course progresses, dependent on the understanding achieved by learners. In the meantime, assessment materials can be incorporated into the Specification Repository for future use (referring to Figure 2).

2. *Course configuration*. A course configuration is carried out based on a subject (or a module), which scopes the relevance of course content to meet the course requirements. This process should consider the selection of a suitable pedagogy for online course design.

There are two repositories which store course specifications and content objects respectively. The course specifications are instances of the course requirements with detailed description of topics, assessment method and criteria. The course specification

and content are structured in a separate repository which comprises the sharable and reuseable objects. One object represents an "element" of the course specifications or subject content with granularities at different level of details.

Course content objects are identified to address subject issues (e.g. concepts, theory and principles) and will be structured as generic as possible so that their reuse between modules is possible, though sometimes customisation to suit a module's specific needs may be necessary. The course content can be internal sources from an institute as well as external sources, e.g., other universities, companies, and the Internet reposities. The contents embody a static view of a course. Delivery Strategy will provide a dynamic mechanism for instantiation (i.e., sequencing) of course contents for a particular class.

A process of the Course Configuration is one of a mapping between the Learning Specification and the Content Repository, which results in a course package. The Content Repository may grow rapidly and become complex as new content objects are created and existing ones are updated with input from the feedback from the learning process. The Course Configuration software will manage these changes.

3. *Course packaging*. A course package is created from the course configuration process based on the specified course requirements. The package is composed by *Course Content* and *Delivery Strategy*. The *Course Content* comprises:

- **Blocks**. The learning content is organised in manageable blocks which relate to the learning outcomes. This would give students support over their learning activities and progress. From the teaching point of view, the tutor can facilitate the learners to achieve their learning goals and also monitor teaching progress participated by the learners. Learning activities of students can be simulated into a Learning Pattern which can be fed back to the Course Configuration for improvements in the course construction.

- **Milestones**. Milestones are associated with the blocks. They allow tutors to know early enough whether the learning outcomes are likely to be achieved so that they can provide guidance to the students accordingly.

- **Assessment**. This is an ultimate learning measurement towards the achievement of learning outcomes and it performs two functions. Firstly, it provides an opportunity for instruction assessment design. Secondly, the actual assessment content and examination papers can be associated with the learning marerials.

The *Delivery Strategy* will support collaboration and interaction between tutors and students and also students and students:

- **Coordination** facilitates learners to carry out learning activities associated with the blocks subject content. During this dynamic process of teaching and learning, appropriate instructions should be provided when there is a need. The instruction should not only serve the purpose of explaining the materials, but also guide the students to develop additional skills such as critical thinking, problem-solving and decision-making.

- **Discussion forum** is where the students and tutors can post questions to and get answers from a shared space. This space encourages student-centred learning by engaging in the discussion to provide for alternative intepretation and understanding of the subject.

- **Personal profile** is used as a personalisation feature for individual learners. The students can be encouraged to participate in the course with initiative and self-management. It also stimulates the development of wider interests in the subject area. By doing so, students can apply their prior knowledge about experiencefor problem-solving. Meanwhile, their learning experiences can be captured and fed back to the *Course Configuration* phase for improvements.

4. *Feedback*. During the course's execution, the activities and experiences of students and tutors should be monitored. The Feedback

component can provide a mechanism to monitor these activities and experiences and feed information to *Course Packaging* phase for improvement of the quality of the course. Some subject content which wasot available in the content repository at the subsequent time of the original construction phase can be incorporated into the repository for future use.

These components can be integrated with the course execution applications which deliver the course to learners. In such way the real-time learning experience and activities can be captured and evaluated. These therefore will be valuable feedback for the course construction.

6. Discussion and Future Work

The teaching and learning theories and paradigms have been practised in the traditional education for long time. The evidence showed that the e-learning can be the innovative means to improve the efficacy and quality of teaching and learning. There are widely used applications in the universities for e-learning, but what is important for the design of the courseware for e-learning is the appropriate instruction and guidelines. This paper has illustrated the collaborative learning environment with its components and techniques to aid the e-learning courseware design. These components and techniques are being experimented in some of the degree courses in our department. A result will be critically analysed and refinements will be incorporated for improvement and enhancement.

Acknowledgment

References
Anderson, M.D. (1998). Critical elements of an Internet based asynchronous distance education course. *Journal of Educational Technology Systems*, 26(4), pp. 383-388.

Beller, M., & Or E. (1998) The crossroads between lifelong learning and information technology: A challenge facing leading universities. *Journal of Computer Mediated Communication*, 4 (2).

El-Tigi, M. and Branch R.M. (1997) Designing for interaction, learner control, and feedback during web-based learning. *Educational Technology*, 37 (3), 23-29.

Cunningham, D. (1987) Outline of an Education Semiotic. *The American Journal of Semiotics*, 5(2), pp 201-216.

Gottfredson, C. (2002) Achieving Maximum Return on Instruction (ROi) with e-Learning, *The e-Learning Developers' Journal – Design Strategies*, September 24.

Jona, K. (2000) Rethinking the Design of Online Course, Keynote Paper, in *Proceedings of ASCILITE2000*, Coffs Harbour, Australia.

Honebein, P.C., Duffy T. and Fishman B. (1993) Constructivism and the Design of Learning Environment: Context and Authentic Activities for Learning, in T.M. Duffy, J. Lowyck and D. Jonassen (eds.), *Design Environments for Constructivist Learning*, Springer-Verlag, NY, pp. 87-108.

Horton, W. and Horton K. (2002) Bring Top Classroom Features Online – No more Boredom! *The e-Learning Developers' Journal – Design Strategies*, October 15.

Liu, K. and Sun L. (2002) Applying Semiotics in Constructivist Learning, International Conf on Teaching and English Translation in the 21st Century, Marco Politechnique Institute, Marco, 10-12 May 2002.

Martinez, M. (2002) What is Personalised Learning? *The e-Learning Developers' Journal – Design Strategies*, May 7.

Peirce, C.S., (1932-35) *Collected Papers of Ch.S, Peirce*, 1931 - 1935, edited by Hartshorne, C. & Weiss, P. (1960) Cambridge, Mass.

Savery, J.R. and Duffy T. (1994) Problem-based Learning: an Instructional Model and its Constructivist Framework, *Educational Technology*, 35(5), pp. 31-37.

Shank, G., Ross J.M., Covalt W., Terry S. and Weiss E. (1994) Improving Creative Thinking Using Instructional Technology: Computer-aided Abductive Reasoning, *Educational Technology,* 34(9), pp. 33-42.

Stamper, R., Liu K., Hafkamp M. and Ades Y. (2000) Understanding the Role of Signs and Norms in Organisations, - a semiotic approach to information systems design*, Behaviour and Information Technology*, 19(1), 15-27.

Schweizer, H. (1999) *Designing and teaching and on-line course: Spinning your web classroom*. Needham Heights, MA: Allyn & Bacon.

Takacs, J., Reed W. M., Wells J. G., & Dombrowski, L. (1999) The effects of on-line multimedia project development, learning style, and prior computer experiences on teachers' attitudes toward the Internet and hypermedia. *Journal of Research on Computing in Education*, 31(4), pp. 341-355.

Uden, L. and Liu K. (2001) Linking Radical Constructivism and Semiotics to Design a Constructivist Learning Environment, *J. of Computing in Higher Education,* 12(2), 34-51.