Supporting Higher-Order Thinking in E-Learning Environment

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Abstract

IT enabled teaching and learning systems have been widely used in higher education institutions. This paper describes how the e-learning environment, such as myCourses, can support teaching higher-order thinking. The theme of this study is the design of organizational structures of teaching and learning artifacts for higher-order thinking. The paper proposes a model of thinking inquiry-based structure of teaching and learning artifact for e-learning management systems. It presents a design case study of implementation of this model.

1. Introduction

E-learning management systems, such as myCourses (Blackboard Vista), have been widely used in education institutions. E-learning management systems are supposed to serve teaching, assessment, and learning [27]. For teaching purposes, an e-learning system posts course syllabi and teaching material. For assessment purposes, an e-learning system records students' assignments and tests as well as assessment results. For learning purposes, an e-learning system can provide an environment for communication, presentation, and collaborative activities. The current e-learning management systems, however, have not been effectively applied to enhancing students' higher-order thinking [16, 25]. This is mainly because generic e-learning management systems are more or less learning subject independent. On the other hand, useful e-learning management systems must meet a variety of needs in learning. Higher-order thinking is active learning process across the boundaries between courses, disciplines, or even fields to learn what the learner has experienced. This challenge raises a significant research question: how theories and practices of e-learning can be applied to e-learning management systems for fostering higher-order thinking.

Artifacts of teaching and learning are learning objects. As discussed in the next section, the literature of learning objects has suggested that an explicit organizational structure of the repository of learning objects can be an interface layer between the user and the teaching and learning artifacts. Accordingly, to make generic e-learning management systems more useful for enhancing students' learning, a layer of the e-learning environment must be developed to facilitate students' higher-order thinking. This paper describes how domain knowledge of teaching higher-order thinking can be used to develop an organizational structure of artifacts to achieve this goal. It proposes a model of higher-order thinking oriented organizational structure of artifacts. The ultimate objective of this study is to build on the theories and cumulative knowledge of IT enabled teaching and learning.

2. Higher-Order Thinking

Higher-order thinking is "an active, persistent, and careful consideration of belief or supported form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" [7]. Higher-order thinking is a thinking process more than simple memorization and comprehension, and involves a variety of cognitive processes, such as summarization, identifying general principles, exploring various situations, reconciling options, monitoring progress, and so on. Although higher-order thinking is a rational process required for problem solving and decision making, it may not directly associate with solving specific problems or making specific decisions. Higher-order thinking has been studies for a long time [6, 10, 13, 17]. There have been many terms for phrasing higher-order thinking in the literature, such as reflective thinking, critical thinking, creative thinking, good thinking, deep thinking, self-learning, etc.

Although the real higher-order activities in the human brain remain by and large an enigma, descriptions of directed thinking routines [20] for the thinking process can make thinking visible as well as teachable. Research [18, 19, 24] has made connections between teaching and learning artifacts and higher-order thinking.

2.1. Higher-Order Thinking Modes and Support of E-Learning Management Systems

In this section, we discuss modes of higher-order thinking in the perspective of teaching and learning higher-order thinking through e-learning management systems. The taxonomy of higher-order thinking has not been made clear. Skeptically, as higher-order thinking is so complicated in general, any taxonomy is unlikely to be applicable to all disciplines. The reason is that discipline-specific and skill-specific knowledge plays an important role in higher-order thinking. Depending on the nature of a discipline, higher-order thinking may or may not directly associate with specific problem solving or decision making. In certain disciplines such as engineering, higher-order thinking may means solving problems using basic and fundamental discipline-specific knowledge. In contrast, for career development or self-regulation, higher-order thinking is generally non-discipline-specific and may not involve any discipline-specific knowledge.

Along with the proliferation of e-learning management systems, there have been discussions on non-discipline-specific higher-order thinking through the use of e-learning management systems [1, 3, 28]. Essentially, three major modes of non-discipline-specific and non-skills-specific higher-order thinking are discussed in the literature: career *development*, *academic accomplishment*, and *extra-curricular learning*. Non-discipline-specific and skills-specific higher-order thinking modes include: *problem solving*, *self-regulation*, and *motivation* [14]. Although higher-order thinking emphasizes general thinking strategies and abilities across diverse situations, discipline-specific knowledge can guide higher-order thinking that is relevant to the particular discipline [9]. Higher-order thinking on *decision making process* [26], *organizational learning* [22], and *system's factors* [5] are examples of discipline-specific higher-order thinking modes in the behavioral science fields.

Clearly, the cut-lines between the higher-order thinking modes can never be sharp. Also, it is not the intention of this study to identify all types of higher-order thinking modes. The focal point of this discussion is to gain more understanding about the different modes of higher-order thinking and to investigate how we can use e-learning management systems to support teaching higher-order in the common modes. Generally, the relationships between the diversified higher-order thinking modes and the support of e-learning management systems can be described in Table 1. As illustrated in Table 1, e-learning management systems can support higher-order thinking in many ways. This study concentrates on the design of interactive teaching and learning environment for higher-order thinking.

2.2. Models of Higher-Order Thinking

As higher-order thinking involves complex cognitive aspects and has a variety of distinct modes, there have been countless models of higher-order thinking in the literature. Nevertheless, models of higher-order thinking can be classified into two categories: procedural model and guiding model.

Procedural model – A procedural model of higher-order thinking describes share common basic stages of higher-order thinking: experiencing, analyzing the situation and knowledge learned from the experiences, and internalizing the learning to generalize wisdom for the future. Kolb's [15] structured reflective thinking cycle model is a representative higher-order thinking procedural model. It asserts that higher-order thinking is an experiential learning cycle which has four stages: concrete experience, analysis of observations, generalization, and planning future action. Similarly, Boud *et al.* [4] describe three-stage activities in higher-order thinking: preparation, engagement, and processing. In the preparatory phase, the learner examines the situation. During the engagement, the learner reviews the experience received from the practice. Finally, a learner must consolidate the experience to apply it in new context. Gibbs' [11] model is another popular higher-order thinking procedural model which we consider to be a variant version of these procedural models of higher-order thinking.

Table 1. Higher-Order Thinking (HOT) Modes and Support of E-Learning Management Systems

Types of HOT Mode	Examples of HOT Mode	Description of the HOT Mode	Support of E-Learning Management Systems
Non-Discipline-Specific Non-Skills-Specific	Career development	Think on personal mission, career selection, and long-term goals.	Accumulative assessments
	Academic accomplishment	Think to plan academic success, and to recognize gaps between the existing knowledge and curricula competences.	Learning portfolios collection
	Extra-curricular learning	Think to celebrate broad life experiences, to develop social skills and responsibility.	Reflection portfolios
Non-Discipline-Specific Skills-Specific	Problem solving	The thinking ability for solving practical problems	Interactive teaching and learning environment
	Self-regulation	The thinking ability to self-monitor and to learn from experiences and mistakes.	Interactive teaching and learning environment
	Creativity	The thinking ability to be effortful and creative.	Accumulative assessments
Discipline-Specific	Decision making	Think for rationale decision making and judgment.	Interactive teaching and learning environment
	Organizational learning	Think to fit the organizational environment and make contributions.	Interactive teaching and learning environment
	Systems thinking	Think on diversified elements and factors of systems and their interconnected relationships.	Interactive teaching and learning environment

Guiding model - Although higher-order thinking emphasizes general thinking strategies and abilities across diverse situations, structured thinking model can guide sophisticated higher-order thinking [9]. Boud *et al.* [4] suggest that structured higher-order thinking is the key to learning from experience. Aram and Noble [2] argue that instructional models of learning and thinking are appropriate for higher-order thinking. Dunne and Martin [8] maintain that, to teach and learn higher-order thinking, we need structured instruments or guidelines, and model is an important tool, if not the only one, that compels higher-order thinking. While the ultimate models of higher-order thinking in great students' mind might not be available, there is little doubt that instructional models can provide guidelines for higher-order thinking. We refer instructional structured thinking models for teaching and learning integrated higher-order thinking to as guiding models. For instance, SWOT (strength, weakness, opportunity, threat) analysis model can provide pertinent guidelines for students to conduct non-discipline-specific higher-order thinking. The decision making model [23] taught in social science fields can help students develop thinking dispositions of decision making. Students can apply this guiding model to any decisions across social science subjects and think about the decision making process as well as the important roles of data and information in decision making.

Clearly, teachers can use typical guiding models, or develop their own guiding models for teaching higher-order thinking.

2.3. Thinking inquiry

Posing questions to the student is an effective approach to teaching higher-order thinking [12, 21]. A guiding model can have its questions, or thinking inquiries, for students to think. A thinking inquiry can be very general. For instance, the SWOT guiding model can have generic thinking inquiries such as: What is your strength in pursuing your career? What is your weakness in your major courses? Do you perceive any opportunity in extra-curricular learning? etc. A thinking inquiry can also be specific to address individual student's work. For instance, the SWOT guiding model can have a thinking inquiry based on a specific situation, such as: What does make your success in the computer literacy courses?

In summary, higher-order thinking procedural models are general frameworks for teaching and learning higher-order thinking, guiding models are tools or instruments for teaching and learning higher-order thinking, and thinking inquiries are detailed instructions for teaching and learning higher-order thinking. Clearly, specific actualized thinking procedures, guiding models, and inquiries always depend upon the teacher's or the learner's own analysis of situations.

2.4. Challenges for E-learning management systems

Higher-order thinking should be a habitual activity. The education community has no doubt that e-learning management systems provide supporting resource for higher-order thinking [28]. Nevertheless, the e-learning community has not demonstrated how e-learning management systems can be effectively used for teaching and learning higher-order thinking. Specifically, organizational structures are still to be developed for e-learning management systems to organize teaching and learning artifacts to support higher-order thinking. To meet this challenge, we propose a model of inquiry-directed e-learning systems. The objective of this model is to gain more understanding about the roles of e-learning systems as an effective tool for teaching and learning higher-order thinking.

3. Embedding Thinking Inquiries in E-Learning Environment

As explained in the previous sections, guiding models and thinking inquiries are the instruments and instructions for teaching and learning higher-order thinking. To make an e-learning environment to be a useful source of artifacts for higher-order thinking, association between thinking inquiries and artifacts becomes the central issue of application of e-learning management systems for higher-order thinking. In this study, we propose two techniques to implement such association: thinking inquiry structure and semantic metadata.

3.1. Thinking Inquiry Structure

A guiding model can involve many thinking inquiries, and a thinking inquiry can have many sub-inquiries. Thinking inquiry structure defines these hierarchical relationships. For example, a SWOT model can have thinking inquiries on strength, weakness, opportunity, and threat. A thinking inquiry on strength can have specific inquiries on strength in verbal communication skills and in quantitative analysis abilities related to all courses. A thinking inquiry structure could be either "standard" for all students or customized for an individual student. A teaching and learning artifact can be linked to the relevant thinking inquiries so that it is integrated into the inquiry structure. A thinking inquiry structure would allow the learner to better understand the overall thinking tasks. It also allows the learner to follow instructions and review all relevant artifacts in conducting higher-order thinking.

3.2. Inquiry related semantic metadata

Inquiry related semantic metadata are keywords that best categorize thinking inquiries. For instance, thinking inquiry "What is your strength in your major courses?" can have keywords such as "SWOT", "academic accomplishment", and "career development". These keywords are semantic metadata that can be attached to teaching and learning artifacts. An e-learning management system can have a semantic metadata dictionary for all available guiding models and thinking inquiries. To associate a teaching and learning artifact with thinking inquiries, one assigns the artifact with relevant keywords.

Note that inquiry related semantic metadata are fundamentally different from content related metadata which best categorize the content of artifacts. For instance, "advertising" is a content related metadata label which might provide useful content information about a marketing case, assignment, or video clip, but is not specifically related to higher-order thinking.

Inquiry related semantic metadata can be useful for a global search for relevant artifacts from the e-learning system repository for a particular thinking inquiry. Clearly, a dictionary of semantic metadata is generated based on specific knowledge of teaching higher-order thinking. From the viewpoint of organization of teaching and learning artifacts, the inquiry structure implements the inquiry-directed organization in a static way, while the semantic metadata do so in a dynamic way.

The above two techniques implement the association between e-learning artifacts and thinking models so that artifacts can be accessed in line with thinking inquiries. The model of inquiry-directed organization of e-learning artifacts for higher-order thinking is depicted in Figure 1.

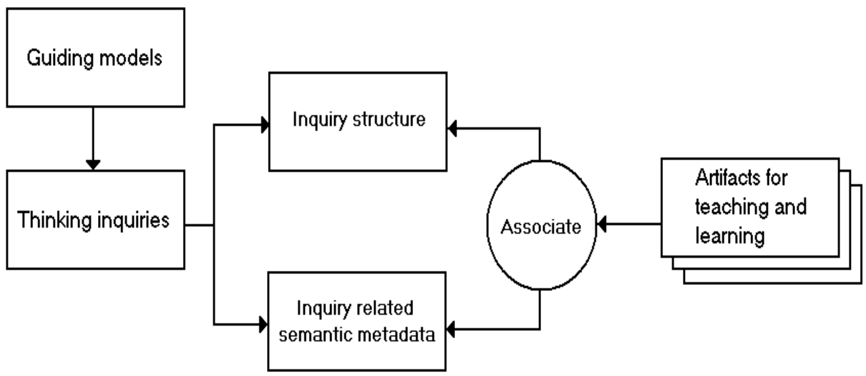

Figure 1. Embedding Thinking Inquiries in E-Learning Environment

4. Fostering Higher-Order Thinking in E-Learning Environment: A Design Case Study

To learn more about embedding thinking inquiry structure in an e-learning management system, a project was conducted to investigate the feasibility of implementation of the proposed model on an existing e-learning management system. We implemented the model on myCourses. We used the myCourses platform to implement a prototype of extension shell of the system, called myThink, for teaching and learning higher-order thinking.

4.1. Context of myThink

Higher-order thinking is conducted on the basis of multiple courses or even multiple disciplines. Commonly, myCourses is used as a web-based course management system on the basis of individual courses. In this case study, we use myCourses as an e-learning environment for fostering higher-order thinking that intersects the borders of individual courses. The myCourses platform does not provide a simple mechanism for integration of multiple courses. myThink is to provide an environment for integration of multiple courses across multiple disciplines. Figure 2 shows the context of myThink with relation to multiple courses in the myCourses system. In a nutshell, myThink is an independent course for teaching and learning higher-order thinking.

4.2. Features of myThink

Here, we present the features of myThink. This is merely to demonstrate the thinking centered organization of teaching and learning artifacts for higher-order thinking, but not the design of thinking inquiries which is a topic independent of this study. The example in Figure 3 shows the course artifact folders in myThink. These folders contain teaching and learning artifacts for individual courses that can be used for support higher-order thinking. Figure 4 shows that the higher-order thinking modes are learning goals which can be linked to learning modules. Figure 5 shows the learning modules for higher-order thinking. The builder is able to build the thinking guiding models and inquiries within the learning modules. Relevant artifacts in course folders can be linked to the learning modules. A teaching or learning artifact can have multiple connections with many learning modules. In the current form of myThink which is based completely on the platform of myCourses system, this is done through physical replication. It has to be admitted that the myCourses platform is weak on implementation of semantic metadata. The search tools of myCourses seldom work adequately in our system. In myThink, a keyword is assigned to the name of a sub-folder within a course content folder, as shown in Figure 6. In such a way, the builder actually defines semantic metadata for the artifacts in the folder. The semantic metadata dictionary of myThink was implemented in an independent folder. When the student conducts higher-order thinking by addressing an inquiry, she is able to find all relevant e-learning artifacts in the corresponding folders. myThink uses the built-in functions of assessment of the myCourses platform.

Our design process clearly demonstrates that the thinking centered organization of e-learning artifacts is derived from the higher-order thinking procedural models, guiding models, and thinking inquiries. We believe that, to construct organizations of e-learning artifacts for planned teaching and learning higher-order thinking, disciplinary knowledge is indispensable.

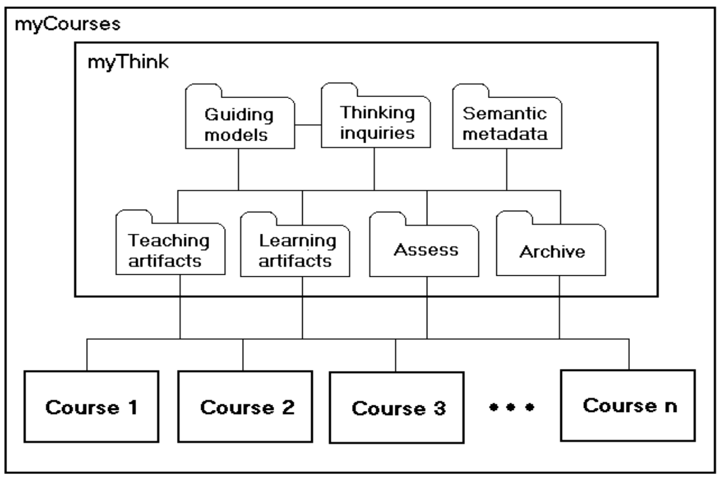

Figure 2. Context of myThink

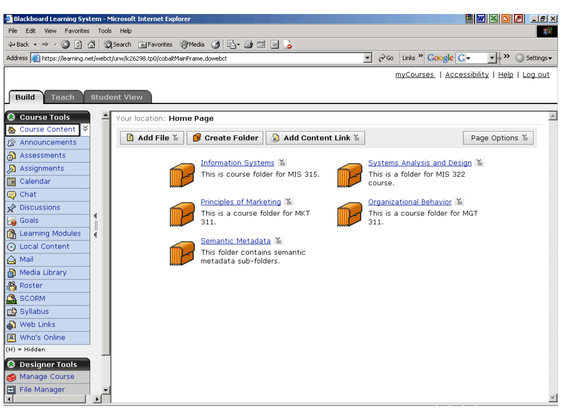

Figure 3. Course Artifacts Folders for Integrated Higher-Order Thinking

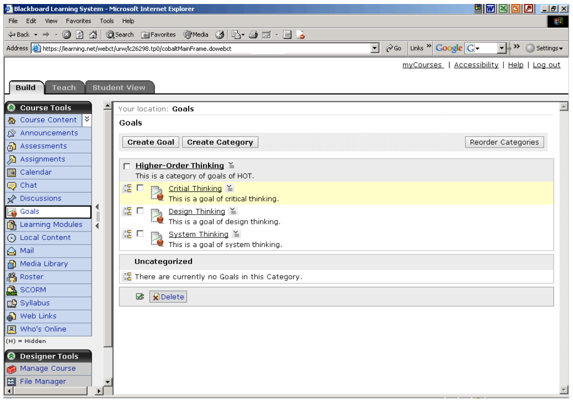

Figure 4. Higher-Order Thinking Modes Are Learning Goals

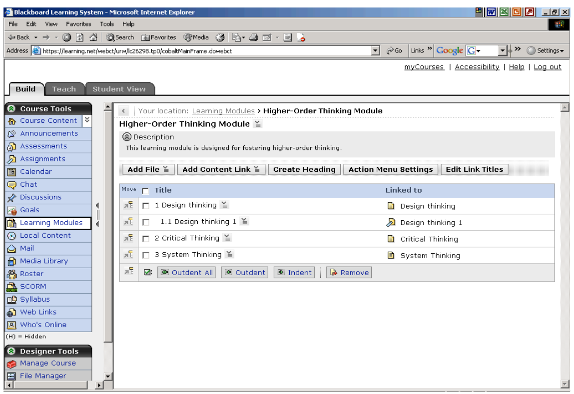

Figure 5. Higher-Order Thinking Learning Modules

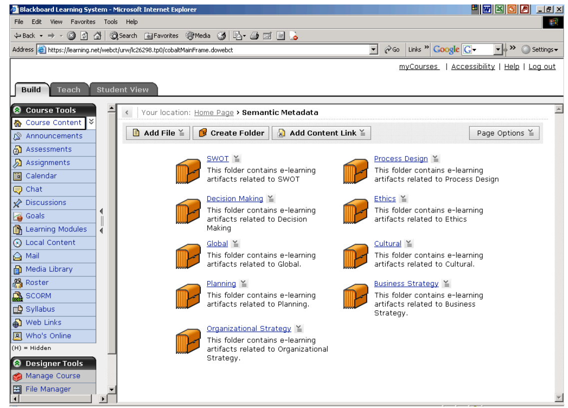

Figure 6. Semantic Metadata Are Built-in Folders' Names

4.3. Discussion on Limitations and Evaluation of the Study

To verify the effectiveness and the usefulness of this approach of thinking-centered organization of e-learning artifacts, rigorous experiments must be conducted. Preferably, test experiments should be carried out by researchers who are independent of the designer to reduce biases. This study has its limitation in that the proposed model and the prototype have not reached practical trials beyond the design experience. While it makes no claim to the validity of the proposed approach, this study is carefully based on the literature of higher-order thinking, and does offer original ideas of construction of thinking-centered organization of e-learning artifacts for teaching and learning higher-order thinking. To make an initial contribution to the accumulated weight of empirical evidence for establishing the validity of this approach, we discuss advantages and disadvantages of the approach, limitations and potential problems of the model, implications for teaching and learning of the study, and candidate criteria for further evaluation, as follows.

The approach is based on the literature of teaching higher-order thinking. The model is generic, and can be readily implemented on existing e-learning management systems, although individual system has its own way of implementation as demonstrated in our case study. On the weakness side, this approach might over-emphasize the structure of higher-order thinking, and thus might exclude variant versions of ill-structured higher-order thinking activities.

This model adds an additional layer between the user and the depository of e-learning artifacts. This layer is a shell; that is, the user ought to provide the needed components for the layer. To apply this model, the teacher has to develop relevant thinking inquiries as well as semantic metadata. In fact, the more systematically the semantic metadata and the thinking inquiries are developed, the more useful the e-learning system would be for higher-order thinking. Furthermore, to use the layer, one must connect an e-learning artifact to the inquiries.

The tedious jobs could be a potential obstacle that interrupts the use of this model.

The effectiveness of higher-order thinking is the key criterion for evaluation of the proposed model. However, it is difficult to find a feasible objective measure of the effectiveness of thinking because higher-order thinking involves complicated human brain activities. Accordingly, we recommend the following subjective measures for evaluation of the proposed model.

- Comparison of the quality of reflection reports that are written by two contrast groups of learners (i.e., one group uses the proposed model and the other does not use it) and are assessed by the teachers.
- Ratings and opinions of teachers on the usefulness of the model for teaching higher-order thinking.
- Ratings and opinions of learners on the usefulness of the model for learning higher-order thinking.
- Ratings and opinions of administrators of academic programs on the usefulness of the approach.

5. Conclusion

The competence of e-learning management systems depends not only on the abundance of artifacts, but also the effectiveness of the use of e-learning management systems for active learning. This paper recognizes a lack of applications of e-learning management systems for higher-order thinking beyond course-based teaching and assessment, and proposes a framework of supporting higher-order thinking in the e-learning environment. The proposed model is based on the premise that higher-order thinking is teachable. It places the focal points on guiding models and thinking inquiries. It adds explicit relationships between the artifacts that would make higher-order thinking more visible. Technically, this study has primarily focused on the thinking related semantic aspects of artifacts for higher-order thinking. Apparently, massive semantic linkages of artifacts for higher-order thinking can be implemented in an e-learning environment.

As an example, we have implemented a prototype of the proposed model through the use of myCourses. Our preliminary case study has shown new challenges for all parties involved in the e-learning community. For educational institutions, there is an organizational need to develop artifacts structures that contain semantic information about higher-order thinking in various disciplines. The artifacts structures should be maintainable to represent the currency of higher-order thinking. For e-learning management systems developers, new techniques and tools are imperative to develop comprehensive uses of e-learning management systems beyond posting teaching materials and assessment. In our view, the proposed model can practically be used for e-learning management systems development. For teachers, new skills of teaching higher-order thinking are required. They must clearly understand artifacts structures of teaching higher-order thinking, and transform unstructured thinking activities to structured tasks based on their own teaching expertise. For students, applications of e-learning management systems for higher-order thinking will be a new challenge of e-learning. In the long run, IT enabled e-learning systems will be indisputable effective tool for active thinking.

In future research, we will focus on the real implementation and formal evaluation of e-learning systems for teaching higher-order thinking. Education institutions, teachers and students shall all participate in the formal evaluation process of the systems.

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