Using an ontological engineering approach to build an engineering education e-Learning system

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ABSTRACT: In this article, the concept of ontological engineering has been used to consider what tasks should be undertaken before building an engineering education e-Learning system. Building the complete contents before users or learners start learning via a website in a network community is difficult for the system designer. Managers and designers rarely consider building a suitable ontology before teaching the material that has been uploaded to the e-Learning system. Even if there is an excellent e-Learning system website, this will not automatically mean good learning results for learners using an online e-Learning environment. Consideration of the problem is made in this article by integrating the input-process-output concept into the system design phase, and uses an ontological engineering approach to build common domain knowledge before undertaking system design and development for an engineering education e-Learning system.

INTRODUCTION

Both traditional classroom teaching and virtual e-Learning environment have inherent and complex relationships and problems. Even traditional instructional design needs to extend and change into system design, and then it must become an instructional system design, without increasing the time and cost for instructional preparation at the same time.

Bordeau and Bates thought long-term instructional planning to be a necessity [1]. Therefore, the purposes of this article include the following:

- Describing the problem of learning methods between traditional methods and e-Learning;
- Drawing on a value-adding model for design of and e-Learning system;
- Constructing an ontology framework in instructional system design;
- Providing an ontological instructional system design process.

Therefore, based on these four purposes, one has first referred to some of the related work on the subject and proposed an approach. The problems between traditional and e-Learning are described in next section. When one understands the problems that can arise in the learning process, a value-adding model of e-Learning for the design process can thus be used. The ontological engineering approach employed in system design is based on the value-adding model of e-Learning for the design process. An ontological instructional system design process is thus shown. Conclusions for gaining explicit knowledge with an ontological engineering approach to creating a valuable design process for engineering education e-Learning can thus be achieved.

PROBLEM DESCRIPTION FOR TRADITIONAL AND E-LEARNING PROCESSES

The traditional learning process is different from the current e-Learning process. Traditional learning processes are based on a face-to-face learning environment, in which teachers provide their implicit knowledge to students. The learning process for the teacher is easier to prepare for and may involve only a classroom, a blackboard and textbooks. Currently, traditional learning has shifted from the classroom to an e-Learning environment, so the learning process has more complexities than traditional learning for the learner and the instructor. The major reason is that the e-Learning process has been accompanied by the rapid growth in information technology, such as with today's mobile learning, ubiquitous learning, and uses technique of Web 2.0 learning on on-line Blogs and Wiki.

However, both traditional and current e-Learning learning processes were faced with the same problem, which is how to create a value-adding learning process for instructors and learners. Because instructional system design is one of the critical success factors in the learning process [2], if e-Learning cannot provide knowledge more explicitly than

traditional learning, the e-Learning process will fail and, therefore, be unsuccessful. Therefore, how to design or provide a value-adding e-Learning system with explicit knowledge becomes a challenge for instructional system design. In order to solve the above problem, it was thought that the instructional designer should use a process-oriented approach to understand how to analyse the e-Learning learning process and find the problems and value. Thus, the concept of operation management can provide effective assistance and could be used at the beginning of the e-Learning system design process.

OPERATION MANAGEMENT IN E-LEARNING

The basic concepts in operation management are input modelling, system process, and output. Hanna and Newman believed that traditional operations management could also create value-adding activities from inputs to the transformation process, and then to the product-service bundle [3]. The inputs included raw materials, labour, capital and information. Finch thought that business needed a plan for creating value [4]. He thought business should not only be concerned with value transferred from suppliers (inputs), but also with value created by the producer or enhanced from material received from suppliers. This means the process of production should add value transferred from suppliers, and value created by the producer (the business itself).

According to these authors, it is known that it is possible to approach the problem from different directions to view the instructional design process (such as an online e-Learning system design and development) in the same way as an input-process-output project might be viewed [3][4]. Thus, when starting, the requirements of the instructional system design and all learning processes should be considered from the learners' point of view. The input-process-output model of operation management can capture the whole learning process, especially as domain knowledge and the learning process can also became a value chain.

- Input: including the system designer, instructor, students, the Internet, software, hardware, and syllabus. The Internet is one of the input materials, and part of the online e-Learning system [5][6]. The syllabus thus can be the knowledge input, for students' learning. However, few studies have focused on using ontological processes for building domain knowledge in web-site contents.
- Teaching or learning process: including interaction, cooperation and communication processes, through which teachers teach and users or learners (students) learn. Through the transferred interactive, cooperative and communicative processes value is transferred from inputs, but there also can be value created by producers (the students themselves).
- Output: including concepts, skills and knowledge.
- Control: that is, quality management. It is known that the first stage of moving is from input to process (teaching or learning materials). If there are any problems in the first stage, the use of an e-Learning system will lead to failure in the final result, because if the input is incorrect, then the output will also be incorrect. Therefore, working out how to control each process with a view of quality management becomes very important.

When process-oriented method modelling is used, all things relating to the e-Learning system, design the e-Learning system of the input, the process and the output can be considered in detail. Therefore, the next task of designing the e-Learning system can be generated: the one that has employed the ontological engineering approach in its design.

ONTOLOGICAL ENGINEERING APPROACH

According to Asunción et al, although ontology aims to capture consensual knowledge in a generic way, and may be reused and shared across software applications and by many groups of people, they are usually built cooperatively by different groups of people in different locations [7]. Bourdeau and Bates thought an intrinsic link existed between Instructional Design (ID) and Distance Learning (DL), because typical instructional conditions also appeared in distance learning including instructional planning, cost analysis, curriculum and course development, instructional materials development and maintenance, delivery plans and detailed evaluation rules [1].

Based on the importance of instructional design for learners in distance or on-line learning, it was learnt that it was a challenge to provide a suitable instruction design for the on-line learning. Mizoguchi and Bourdeau focused their studies on instructional design and have provided a direction for building an ontology-aware authoring system in past years [8]. They thought that ontology provides with an effective methodology and vocabulary for both analysing and synthesising knowledge-based systems and ontology that is devoted to research from an engineering point of view is regarded as ontological engineering. In their investigation, they provided the idea of a road map, which was a system of how to communicate with human knowledge in Intelligent Instructional System (IIS).

Ontological Engineering (OE) can be an effective methodology for building intelligent instructional systems, and Bourdeau and Mizoguchi [9] also indicated that ontological engineering can be used as a collaborative process jointly conducted by an OE expert and an ID expert on a roadmap towards a theory-aware Intelligent Tutoring System (ITS) authoring system. Inaba and Mizoguchi also introduced their Learning Design Palette which was a cost-effective and ontology-aware authoring system for learning design [10]. In their study, the Learning Design Palette with some

international standards (such like Sharable Content Object Reference Model, called SCORM) was used to enhance share ability and reusability of learning design.

Ullrich described the ontology of instructional objects, which captures the educational *essence* of a learning resource, and this *essence* from a teaching/learning perspective. The ontology can then be mapped onto several knowledge representations in today's e-Learning systems, and can benefit educational Web services [11].

Chin et al developed an ontology-based knowledge organisation framework for information technology, and they intended to design and develop IT-related curricula [12]. Their study also used an integrated approach for both the ontological view of the IT pedagogical knowledge hierarchy and ontological representation of a pedagogical system, and then established a mapping between competencies and layered IT pedagogical knowledge organisation.

AN ONTOLOGICAL E-LEARNING SYSTEM DESIGN PROCESS

From above material, it was learnt that instructional design is very important to both traditional teaching and distance learning (e-Learning). In particular, some researchers progress using an ontological engineering approach to improve instructional design for intelligent on-line e-Learning community systems. Usually, e-Learning is well-known using the website environment for interactive, cooperative and communicative dialogues between learners and instructors [5][6].

An instructional designer should consider more conditions that relate to traditional instruction design than to e-Learning instructional design. Inaba et al indicated that the instructional design process consisted of such stages as the analysis, design, development, implementation and evaluation in their study [13].

Based on the five phases of the instructional design process, the system designer can configure his/her design-fitted goal of instructional design. However, the five phases of the instructional design process are not enough for the current e-Learning system design. They are not considered as domain knowledge to design; therefore, both previous concepts of the learning process, operation management and ontological engineering must be integrated into an instructional system design process. Thus, this approach is an ontological e-Learning system design process and each of the phases is explained below:

- Phase 1 - Input-output analysis: detailed description of process-oriented systemic analysis method, such as operational management to understand the problems of e-Learning.
- Phase 2 - Valve chain modelling: used operational management methods to draw a value-adding model for an instructional system design of e-Learning.
- Phase 3 - Ontological instructional system design: an ontological engineering approach to the instructional system design process.
- Phase 4 - e-Learning website development: when designer has finished from Phase 1 to Phase 3, then, he/she can view the instructional system design process as domain knowledge. This ontology includes task-level ontology on the second level such as system designer, teacher, student and teaching classroom respectively. Each task also has its own domain-level ontology; for example, the teacher's task is to upload the teaching material to e-Learning system (website). Hence, teachers need to prepare their syllabus and curricula, and then must prepare the contents of the teaching subject, according to the designed curricula.
- Phase 5 - Quality evaluation: the last phase is quality evaluation. The core concept is value-adding in all the designed processes. Because learning is a valuable operation process, the primary process of materials through system transformation becomes valuable for the learner. Hence, the quality of each process or step should be controlled.

CONCLUSIONS

When an e-Learning system designer wants to design an on-line engineering education e-Learning community system, he/she not only needs to consider a systemic design and development, but must also to consider some of the problems, before attempting the design and development phases. Because the system design process is in its nature process-oriented, the designer should consider the requirements of the users or learners, which is not always the case. Therefore, they may have lost some of the important factors critical for the users or learners (including the perspective on domain knowledge).

In this article, the concepts of operation management and ontological engineering are used to view the problems outlined above. To reduce the problems for on-line engineering education e-Learning system design, concepts of operation management were used to build the Input-Process-Output model before the online e-Learning system was designed. It was done by thinking about how to build a suitable ontology for the task that should be considered to be the domain knowledge of instructional system design. The designer can then provide the related teaching materials for the users or learners based on the common ontology. It is, therefore, possible to achieve the goal of building an on-line engineering education e-Learning system with the application of ontological engineering in computer educational environment.

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