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A Web-Based Handbook of Innovative Teaching Practices - Creating New Opportunities for IS research

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Abstract

Process-oriented learning designs *describe innovative teaching practices (processes) that consist of a set of inter-related learning tasks. These processes are generic rather than discipline specific. An example includes a problem-solving process widely used in problem-based learning. Most existing process-oriented learning designs are not analysed or documented in any systematic way. This is because they represent tacit knowledge gained through years of practical experience and reflective practice. Consequently they are hard to externalise and support by information technology. This paper investigates the dual role IT technology plays in relation to process-related learning designs. It argues that existing educational technologies, knowledge-management systems and process-oriented technologies cannot be used to support process-related learning designs. Furthermore, these existing technologies cannot be used to offer knowledge management support to teachers interested to share, store and reuse their innovative practices. The paper describes a new type of process-oriented, knowledge-management educational technology designed to fulfil this dual role. The paper also identifies various interesting IS challenges related to the design and implementation of this technology.*

Keywords

Educational technology, Innovative learning activities, Learning designs, Knowledge-management

INTRODUCTION

The ability to learn how to learn has been widely recognised as one of the most important skills that students should acquire during their higher education today. To help students build these skills, it is necessary to engage them in carefully planned process-oriented learning activities rather than isolated learning tasks (Race, 1999). These activities should include a number of inter-related learning tasks that promote active learning through collaboration, critical thinking, problem solving and authentic interactions with the real-world problems. Also, to help students become more "self-regulated", reflective learners it is necessary to develop their awareness of the process itself. In some cases, going through the process is equally important as the final outcomes themselves. For example, in problem-based learning, knowing how to solve problems in a particular domain is as (if not more) important then the final solution.

To describe these educational processes (innovative activities) more formally, this paper adopts the terminology introduced by Oliver et. al. (2002). The term *learning design* has been adopted to describe various components of learning experiences including for example teaching resources, tools and innovative teaching strategies. So far, learning designs have been mostly *resource-oriented*. This means that the main emphasis has been placed on educational content and tools for content presentation, delivery and management.

This paper deals with a particular type of learning designs called *process-oriented learning designs*. They are used to describe *process-oriented innovative teaching practices* (activities) that consist of a set of interrelated learning tasks. These activities are generic, rather than discipline specific. They could incorporate both face-to-face and technology supported tasks (including on-line tasks). Consequently, they could be used both in mixed mode as well as in e-learning. It is important to point out that the term "process-oriented learning designs" is more appropriate than "learning process" that is widely used in educational research to describe cognitive processes of learning rather than teaching/learning practices.

Some process-oriented learning designs have became widely known and accepted across different disciplines, for example the problem-solving process that forms a foundation of problem-based learning. There are many variations of the problem-solving process in practice. However, most of them include a set of common tasks such as: identification of a problem, alternative evaluation and selection of the course of actions for the chosen alternative. In addition to the problem-solving process, there are many more processes used by different disciplines that could be also generalised (e.g. the balanced scorecard method).

Design and implementation of process-oriented activities in any teaching discipline is much more challenging than implementation of individual learning tasks. Process-oriented learning designs are hard to design and implement because they are, in fact, *knowledge-intensive innovative processes.* In the traditional teaching and learning setting, these processes are invented by individual enthusiastic teachers and refined though years of practical experience and reflective practice. From the knowledge-management perspective they are *tacit* knowledge gained through years of practical experience of looking for the answers for a simple question: "How do I help my students achieve the intended learning objectives for this particular activity/topic/course?" This is the main reason why most of the existing process-oriented learning designs are not described or analysed in any systematic way. Consequently they are hard to share across disciplinary boundaries.

On the other hand, this knowledge sharing is becoming increasingly important not only to help the less experienced teachers. More and more teachers need to share their experiences simply to keep up with ever changing technologies or to meet different student expectations (especially in the area of IS/IT/CS education where most students expect their teachers to use sophisticated educational technology). Furthermore, some universities are in the process of implementing various institutional strategies to encourage knowledge sharing among teachers that will over the time result in much better student learning experiences (see for example UNSW's teaching and learning guidelines (UNSW, 2004)).

Because process-oriented designs are hard to describe and share across disciplinary boundaries, they are even harder to support by information technology. In fact IT plays a dual role here. On one hand it can be used to support the implementation of process-oriented learning designs and on the other hand it can be used to support teachers to share, modify and reuse their innovative practices across disciplinary boundaries.

This paper aims to further investigate the dual role technology plays in relation to process-oriented learning designs. More precisely, the main objectives of this paper are to:

- analyse the relevant literature to describe why the existing educational technologies, process-management technologies and knowledge management systems cannot be used to effectively support process-oriented learning designs.
- describe a new type of educational technology called *web-based handbook* of process-oriented learning designs
- identify interesting IS challenges arisen from design, development and use of this new type of educational technology

RELATED WORK

This section summarises the relevant literature to illustrate to what extent the existing educational technologies, process-oriented technologies and knowledge-management systems can be used to support the implementation of process-oriented learning designs as well as offer knowledge-management support to teachers interested to share and re-use elements of their innovative practices.

Supporting process-related learning designs

During the last decade, a number of web-based educational environments have been developed and deployed by many universities all around the world. Examples include WebCT, Lotus LearningSpace, TopClass, etc. If one ignores different "look and feel" of these packages, their main features can be summarised under several very broad categories:

- *authoring and presentation tools* such as text and graphics editing environments, automatic glossary and index generation, generation of course meta-data etc.
- *assessment and feedback tools* such as automatic quiz generation including a variety of types of questions
- *student management tools* including grading and reporting
- *administrative tools* including managing user accounts, updating software and security management
- *collaborative tools* including synchronous and asynchronous collaborative tools such as bulletin-boards, news groups, chat rooms, audio/video teleconferencing, electronic whiteboards etc.

In essence, currently available educational technologies are task-oriented rather than process-oriented. They offer tools to support communication and collaboration tasks, however they do not offer the adequate support for coordination that is the key ingredient for process support.

On the other hand, in the area of business, such a support is already available in the form of process-oriented technology called workflow. This technology has been widely recognized as the leading process-oriented technology (Workflow Management Coalition). In essence, workflows are designed to specify, execute, manage, monitor and streamline business processes by allocating the right task to the right person at the right point in time along with the resources needed to perform the assigned task. Workflow technology enables coordination of different tasks as well as integration of tools and technologies used to support individual tasks.

Although it is primarily business technology, workflows can be used in education. For example the tool called Flex-eL (Marjanovic and Orlowska, 2000) used a predefined process model to guide students through a set of learning modules. Another project described by (Van der Veen, Jones and Collis, 1998) used workflow technology to support management of student projects.

However, in spite of its process-orientation, workflow technology is not directly applicable to process-oriented learning designs for several reasons. Its main objective is to support fully structured processes where task schedule is pre defined and cannot be easily changed during process execution. This is not flexible enough for the process-oriented learning designs. Furthermore, in unstructured problem-solving activities, learning designs evolve (emerge) as students are exploring different alternatives. In fact, support for emergent processes is a very recent research area of business process management. Consequently, technologies and modeling frameworks are not yet widely available (Carsen and Jorgensen, 1998; Marjanovic, 2004).

Using technology to store, share and reuse process-related learning designs

One of the major challenges in the area of computer-supported education today is the development of a framework based on sound pedagogical principles that will promote the exchange and interoperability of learning concepts, materials and teaching strategies (IMS Global Learning Consortium), (Oliver et. al, 2002), (LOM Standard). Various attempts to meet this challenge have resulted in several major educational technology standards (such as Learning Object Model (LOM)) being proposed and adopted. This, in turn, has lead to the growing number of learning objects (e.g. educational resources) that could be shared across different educational platforms.

However, these standards were not invented to enable teachers to model and share learning designs, but to enable exchange and reuse of educational materials by different educational environments (software packages). In fact, currently available modeling languages, invented and used to specify these learning objects, are complex for non-IT specialists (for example XML based). Furthermore, the emerging standards still concentrate on static resources (e.g. educational materials and resources) and do not support specification, execution and exchange of dynamic structures such as process-oriented learning designs.

As already pointed out, design and sharing of process-oriented learning designs is also a knowledge-management challenge as they represent *experiential* rather than widely available *external* knowledge that can be easily shared. In fact, one could claim that process-oriented learning designs have a very long-history (probably as long as formal education). When dealing with process-related learning designs teachers are, in fact, involved in four fundamental knowledge processes (as described by Alavi and Leinder, 2002) including (1) creation, (2) storage/retrieval, (3) transfer and (4) application of knowledge. However, currently available knowledge-management systems are still limited when it comes to process-related knowledge management (Alavi and Leinder, 2002; Malhotra, 2002; Marjanovic, 2004). The required knowledge-management support cannot be provided by the existing educational technologies either.

In summary, the practice confirms the need to support the implementation of process-related learning designs by technology. It is also necessary to support teachers interested to share and re-use their innovative practices across disciplinary boundaries. This knowledge sharing will enable teachers to create process-oriented learning experience for their students very different from what is currently possible with the leading commercial educational technologies. To fulfil these goals, different type of educational technology is required. This paper aims to introduce such technology and describe the associated IS (Information Systems) challenges.

MOTIVATING EXAMPLES

The following simplified examples illustrate typical process-oriented activities that many teachers are already using. Suppose that both teachers A and B are interested in implementation of problem-based learning in an assignment they are about to give to their students. Recall that in problem-based learning going through the process is as important as the outcome itself. Obviously, this has to be clearly stated within the learning objectives for this particular assignment.

The first example comes from Oliver and Omari (2001) who used the following scenario to illustrate how technology can be used to support problem based learning: Teacher A posts an authentic problem on the course web site along with links to various learning resources and questions for self reflection. The teacher also specifies the deadline for submission of a solution that students are required to post on the web site. Students are expected to use discussion tools (forums) to discuss the given problem and come up with a solution. Then students are required to post a short summary of their solution on the web. They can also check other postings. After all solutions are posted, the teacher will mark each summary.

In the second example, suppose that teacher B is in charge of a postgraduate course. In this assignment, students are required to solve a complex unstructured problem. Teacher B is interested not only in the final solution, but also in the problem solving method (steps) students used to solve the given problem. At the beginning of their assignment, teacher B requires students to register their groups (via e-mail) and allocate roles to individual members. Then, students are also required to submit the intended project plan within two weeks. Students are also expected to find the relevant learning resources (e.g. journal articles, web sites etc.) and share them within their own group. In order to support their group work, students are given access to various communication and collaboration tools.

Teacher B also wants to implement a form of peer-review because she believes that students can also learn from reading and commenting on other assignments (after they have been submitted). To comply with the current university policy on student privacy, suppose that students agree to participate in peer marking. So, after all assignments are submitted, the teacher marks each assignment. Then, for each assignment she selects another group of students that will play the role of reviewers and sends them the allocated assignment. The reviewers are not supposed to mark the allocated assignment but are required to comment on the proposed solution. They send their comments to the teacher along with the allocated assignment. The teacher then give the reviewer group a number of additional marks based on the quality of their comments.

Supporting this particular process-oriented learning design by existing educational technologies is not as simple as it may look like. First of all, even though students have access to different collaboration and communication tools, these tools are not integrated in any way. Also, these tools do not support coordination. Therefore, in order to coordinate individual tasks, teacher B (as well as her students) will need to exchange and keep track of a number of e-mails making sure that students' activities comply with various given deadlines (e.g. for group registrations, project proposals, assignment submission and peer-review). She will also have difficulties in monitoring students' progress especially in terms of problem solving stages (steps). The only way she could do it, to some degree, is to analyse the messages students post on the topic forum.

When it comes to knowledge sharing, unless these two teachers A and B have a chance to exchange their experience related to the practical implementation of problem-based learning in their respective courses, their practices will remain within their individual courses or disciplines. Therefore it may never occur to teacher A to use peer-review in his course. Teacher B could also benefit from teacher A's experience with the same learning design but in a different course/discipline. The following section aims to introduce a new type of educational technology that could help these two teachers to implement their respective learning designs more effectively as well as to share the acquired knowledge and experience.

WEB-BASED HANDBOOK

This section gives a brief overview of a new type of knowledge-management, process-oriented technology called the *web-based handbook* of process-oriented designs. Design and implementation of the web-based handbook is a complex multidisciplinary research and development problem that requires integration of knowledge, tools and methods from several different disciplines, as depicted by Figure 1.

The main motivation behind development of this technology is to enable teachers to retrieve, store, modify, re-use, share and assemble the executable components. These components are self-contained modules used to implement one or more process tasks. By combining individual components, teachers can create and implement various process-oriented learning designs without any programming involved. Recall that these technology-supported tasks could be also combined with various tasks not supported by technology (e.g. face-to-face activities).

In order to design this technology it is important to start from understanding and modeling of learning designs invented by teachers from different disciplinary areas. In order to describe their innovative practices (i.e. externalise their tacit knowledge) teachers need to adopt the activity-centered approach to instructional design. This means starting from the intended learning objectives and then describing a set of inter-related tasks designed to achieve these objectives along with the educational resources and tools that may be made available to students.

These learning designs are then documented by a knowledge engineer in a form of process-models. In the next step, the knowledge engineer analyses these models in order to identify possible generic patterns. These patterns are then used as the basis for development of various executable components. When completed and tested, these components are then stored in the knowledge repository and made available to teachers.

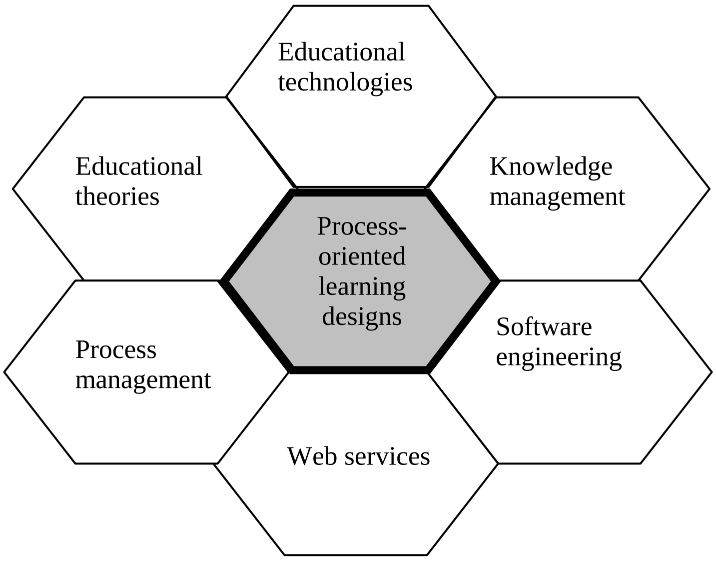

Figure 1: Web-based handbook - a multidisciplinary framework

Web-based handbook architecture is shown on Figure 2. There are two main categories of handbook users: knowledge engineers and end-users (teachers). Before teachers can start to use handbook, the initial set of components need to developed by knowledge engineers and stored in the knowledge repository.

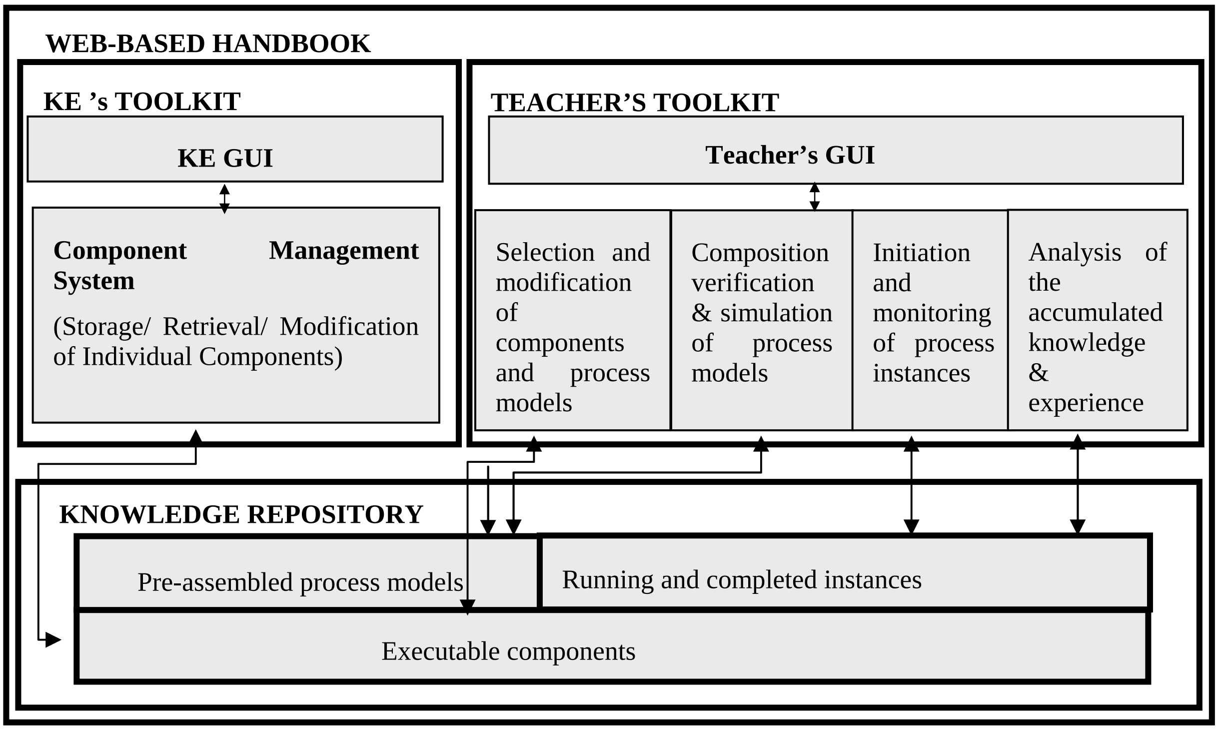

Figure 2: Web-based handbook

After the initial set of components is developed and stored, knowledge engineers use the *Component Management System* to manage knowledge repository (store/retrieve and modify executable components via specially designed Graphical User Interface (GUI).

When components are made available, teachers can use their toolkit to perform the following process-oriented activities:

- Select the executable components from the repository to support individual learning tasks (e.g. electronic brainstorming) or sub-processes (e.g. peer-review of assignment that consists of several steps). Teachers should be able to search for the exact or similar components that will be used to support a particular task. They should be also allowed to modify the given component to suit the needs of the particular group of students and the intended learning objectives.
- Assemble the selected components into a process (learning activity). In addition to individual components, teachers should be able to reuse a pre-assembled process that had been composed and tested by other teachers. Therefore, process models should be also stored in the repository. Processes can also incorporate tasks that do not require any technology support (e.g. face-to-face meetings). However, the model will still contain descriptions of these tasks, as their outcomes need to be recorded for knowledge sharing purposes. Furthermore, not all components need to be identified in advance. Therefore, teachers should be able to add or remove components during the actual execution of the process.
- Verify that the resulting process is consistent and valid. For example, teachers should be able to check if it is possible to complete the whole process within the required time (e.g. within 6 weeks) based on the duration of individual components and well as to verify if the components are assembled in the right logical order (e.g. peer marking comes after assignment submission).
- Monitor process instances - as teachers and students progress through the process model, new tasks will appear on their to-do lists and the required tools will be available in their shared and private workspaces at the right point of time. Teachers should be able to change process models during run-time to add new tools and components and/or remove and modify the selected ones. Instances of the running and completed processes are also stored in the knowledge repository.
- Analyse the accumulated experience related to various process models and their practical use. Based on this analysis, they should be able to create better process models in the future.

USING WEB-BASED HANDBOOK

Going back to the examples of process-oriented learning designs introduced earlier in this paper, suppose that both teachers A and B are given access to the web-based handbook. The following are some examples of the possible components that could be stored in the knowledge repository:

- *Problem registration* – This component enables teachers to post the assignment on the web. Students will be automatically notified that the assignment is ready via e-mails. This will also generate a temporal constraint (submission deadline) that is used for verification purposes during model composition as well as process instance.
- *Registration of groups* – When this component is used, students will receive an invitation to register their groups by the given date. Teacher can configure this component to automatically form groups of all students who fail to register by the deadline.
- *Problem-solving component* **–** For example this component can include a number of sub components both generic and subject specific such as electronic brainstorming, mind-mapping, alternative analysis or collaborative design of ER diagrams.
- *Assignment submission component* – This component can be designed to work similarly to conference paper submission system or simply to remind the students of the approaching deadline and issue a confirmation that the assignment has been submitted.
- *Peer-review component* – This component could be configured by the teacher in a variety of ways to support different roles and coordinate tasks accordingly. For example, the same item can be marked only by the lecturer or by two different groups of students or even by an external marker.

Even with this small number of components teachers can create several different combinations of learning designs. For example, teacher B could assemble all the above components into a process, while teacher A could decide to use only “problem registration” and “assignment submission” components and supplement them with traditional face-to-face problem solving activities. Teacher C could decide to use the electronic debate instead of the electronic brainstorming tool etc.

In essence, as all these teachers gain more and more experience in using web-based handbook, they will be able to invent further components and delegate their implementation to knowledge engineers. Once components are developed and stored in the repository, all users (with valid access privileges) will be able to share and reuse the stored components, process models as well as learn from the stored process-related experience.

WEB-BASED HANDBOOK – IS RESEARCH CHALLENGES

Design and implementation of the web-based handbook is a complex research and development problem that cannot be solved by a simple integration of the existing methods and tools available in the related areas (as depicted by Figure 1). This section summarises interesting IS challenges related to the possible support that can be offered to knowledge engineers involved in the design and implementation of executable components as well as teachers using web-based handbook.

Supporting knowledge engineers

During development of the initial set of executable components, knowledge engineers face the following research challenges:

- *Conceptual modeling of process-oriented learning designs*: There are many available process-oriented modeling languages that could be used to create conceptual models of process-oriented learning designs (e.g. UML). However, the chosen modeling language will need to be extended to represent various educational aspects (learning objectives, different types of learning resources etc.). Furthermore, after the models are created another challenge is to verify their consistency.
- *Analysis and further improvement of the conceptual models*: The obtained conceptual models need to be analysed to identify possible improvements (i.e. the alternative ways of achieving the same learning outcomes). This improvement is only possible if both knowledge engineers and domain-experts (teacher) work together.
- *Identification of patterns in conceptual models*: This is a knowledge management challenge that requires knowledge engineer to abstract models out of the specific disciplinary context and identify possible executable components.
- *Implementation of executable components*: This is an IS development problem. In order to enable composition of components and their re-use it is necessary to make them self-contained and configurable. The emerging area of web service research and implementation opens up new possibilities to implement executable components as web services. However, further investigations of issues related to web service composition and deployment in the educational domain is required. This includes educational, technical, organisational, legal and social implications of offering learning designs as web-services.
- *Integration of the existing educational tools:* The existing educational tools and resources (e.g. chat and bulletin board tools) need to be integrated within the web-based handbook. However, to make this integration possible, it is necessary to extend the existing standards (such as LOM) to enable process-support. Integration of the existing tools and resources could be possibly achieved through web-services. However, currently available process-oriented standards in the area of web services are designed to enable description of business processes rather than educational activities.

Supporting end-users (teachers)

After the web-based handbook is initialised i.e. knowledge repository is populated with executable components, it is ready to be used by teachers, provided that all described tools from the teacher's toolkit are available. Using of web-based handbook involves the following challenges:

- *End-user process modeling*: The first challenge here is enabling teachers to select the most suitable components from the repository and to create a process-oriented design for the intended set of learning objectives. To do this, teachers should be given a simple, user-friendly graphical user-interface designed to hide the details of technical implementation of each component. Furthermore, as teachers may not know which component to select, they should be able to search and browse the repository and even look for the "similar" components in terms of learning objectives. Furthermore, teachers need support to verify process consistency (e.g. is it possible to complete all intended activities by the given deadline). They should also be able to simulate process execution before they start using it in the class. Teachers could also search for complete models developed by others (instead of individual components) and configure these models to suit the intended learning objectives.
- *Execution of created process-related designs:* This includes issues such as monitoring of student activities and deciding if the designed process is achieving the intended learning outcomes. Furthermore, teachers should be able to dynamically change the model at any point of time and make sure that what they intend to do is again consistent. Another equally challenging research problem includes support for emerging (unstructured) learning designs that evolve with the experience.

- *Storing process-related experience*: In addition to process content (i.e. record of the actual tasks) it is also necessary to store process context. This is critical for knowledge sharing and proper interpretation of process experience.
- *Analysis of the accumulated experience:* In order to analyse the accumulated process-related experience, it is necessary to "mine" the completed processes stored in knowledge repository. However, the problem of process mining is much more challenging than data mining.

Supporting the transfer of knowledge between teachers and knowledge engineers

It would be unrealistic to expect teachers to design executable components. Therefore, to enable knowledge repository to grow it is necessary to enable transfer of knowledge between practitioners (teachers) who are creating knowledge by creating and using process-oriented designs and knowledge engineers who are in charge of development of executable components. This task can be very challenging in some organisational settings. It will require re-thinking of the concept of "IT support" used with current implementation of various educational technologies.

Furthermore, over the time some teachers may be able to identify possible components from their own experience and delegate their development to knowledge engineers. Some teachers may even develop component themselves. Initially this is more likely to happen among teachers who have both: domain knowledge as well as IT expertise. As knowledge repository grows over time, teachers will be able to create many innovative processes just by creating different combinations of the available components.

Organisational issues related to adoption of this technology

There are number of organisational issues that need to be investigated. In addition to "standard" issues related to adoption of any new technology in an organisation there are some issues that are specific for the educational environments: such as intellectual property, the existing skills of teachers, willingness to share innovative strategies, organisational support, security and privacy especially if learning designs are offered as web services.

The widespread adoption of WebCT (which is relatively simple platform to use) has shown that the process of adoption of new educational technologies is not simple. However, the same example has also demonstrated that adoption is possible (obviously if technology is perceived to be useful) in spite of the initial technological barriers. For example, what used to be an "impossible" task some 10 years ago (e.g. to get non-IS teachers to design a simple course web page) is relatively simple (or less challenging) these days thanks to the efforts of many teachers and their willingness to share their ideas. This experience has resulted in development of new user-friendly tools.

Finally, it is necessary to design a number of new instruments to evaluate the use of web-based handbook by teachers as well as the effect this knowledge sharing among teachers will have on learners. Obviously, this is another very challenging research task.

CONCLUSIONS AND FUTURE WORK

Process-oriented learning designs are used to describe innovative learning activities that comprise of the set of related learning tasks. These processes are generic which means that they can be used across different educational disciplines. Process-oriented learning designs are at the core of socio-constructivist theory of learning as there is strong evidence that students learn more then they are actively involved in a process rather than isolated learning tasks. Consequently, there is a need to create and share process-oriented learning designs among teachers, especially in the world where information technologies constantly change what is possible.

This paper analyses the dual role that technology plays in relation to the process-oriented learning designs. More precisely, it analyses how technology can be used to implement innovative teaching practices as well as to enable knowledge sharing among teachers. The paper then describes a new type of process-oriented, knowledge management educational technology called the web-based handbook. Design of this technology is based on the multidisciplinary research framework that spans across six different area of research: the existing educational theories, educational technologies, knowledge management, software engineering, process management and web-services. Finally this paper identifies interesting IS challenges related to the design, development and implementation of the web-based handbook.

Development of the prototype of the web-service handbook of process-oriented designs is currently in progress. It is envisaged that after the initial small-scale implementation and evaluation, this prototype will be made publicly available on the worldwide web. Current and future work include further investigation of the identified research challenges related to both implementation and deployment of this new type of educational technology.

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