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Development of a personalized e-learning model using methods of ontology

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Abstract

A number of recent studies are trying to improve the quality and effectiveness of e-learning using principles of several research areas. This trend of personalization development also appears in e-learning. One of the ideologically closest fields of science is knowledge management (KM). The aim of this article is to identify overlapping points of KM and e-learning phases to improve the structure and transfer of personalized course knowledge using effective methods of ontology and metadata standards. This research offers a theoretical background of knowledge management principle implementation for the development of a practical personalized e-learning model.

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1. Introduction

Research shows that every student consumes training material based on their own unique learning style, needs and interests. There is a tendency to claim that personalization is an immanent feature of e-learning. Content placed within an e-learning platform, easily accessible from any place at any time, seems to fulfill individual needs of learners. However, easy access to learning content does not ensure better teaching and learning results¹. E-learning

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platforms currently in use generally do not include features to provide a personalized learning approach, and the same materials and activities are visible to all students.

Personalization is described as adapting the learning experience to different learners by analyzing knowledge, skills and learning preferences of individuals². Personalized learning removes time, location and other constraints of the teaching process and aims to tailor teaching to each learner's constantly changing needs and skills.³ Personalization in the context of computer science refers to the ability of a system or application to adapt to the needs of each user.

By exploring the concept of personalization in e-learning, the authors define three main directions of development:

- A Student's personality - learning styles.
- Structure of information - semantic web.
- Technological approach⁴.

With the increasing popularity of the personalization idea, interdisciplinary research becomes more and more popular, also in e-learning. There is a number of recent studies that are trying to improve the quality and effectiveness of e-learning using principles of different research areas. One of the ideologically closest science directions to e-learning is knowledge management (KM). Traditionally, KM is understood as the management of company's knowledge, but in the learning process the public knowledge of students is also managed. The E-learning and KM information lifecycles are similar: both involve the creation of useful knowledge from information or data found in available resources.

In previous research papers the authors developed a theoretical framework for a personalized e-learning model⁵. The theoretical framework is based on four basic blocks of personalization (see Fig. 1): student personality, knowledge level, course content and technologies.

Each of the blocks targets a different aspect, therefore it is possible to achieve the broadest level of personalization.

In respect to KM usage, it is possible to improve student course content and technological, as well as knowledge level blocks. These improvements are based on standardized and structured learning materials and technology descriptions. To provide these enhanced KM technologies, learning objects such as metadata and ontologies will be used.

This paper discusses knowledge structuring and transfer as an overlapping point of KM and e-learning.

The aim of this article is to identify overlapping points of KM and e-learning phases to improve the structure and transfer of personalized course knowledge using effective methods of ontology and metadata standards.

The structure of the paper is as follows. Section 2 identifies possibilities of KM phase adaptation for the e-learning process. Section 3 will offer a theoretical and practical background of using learning objects in e-learning development. Section 4 and in Section 5 offer possible uses of metadata and ontologies in e-learning. Section 6 proposes concluding remarks and future work.

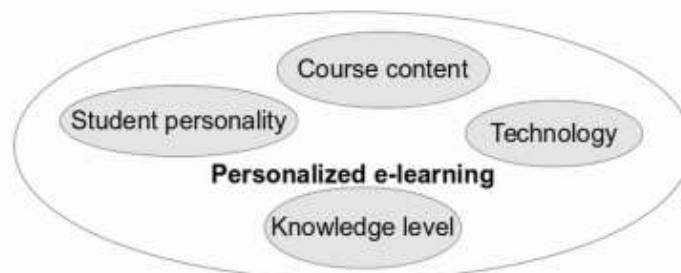


Fig. 1. Four blocks of personalization in e-learning.

2. Adaptation of knowledge management phases in the e-learning process

Different researchers have used different approaches to define KM in their literature. Singh et.al.⁶ classified them with different theoretical perspectives namely Need of KM, What KM demands, KM practices, KM and IT, KM processes, and Holistic nature of KM. While Holm⁷ define KM as a process: getting the right information to the right people at the right time, helping people create knowledge and sharing and acting on information.

KM tasks and activities can be classified into a framework of the conversions between tacit and explicit knowledge (see Fig. 1). Based on this framework, there are five phases of KM that aim to increase an individual's tacit knowledge for solving business problems⁸:

- Socialization: Transfer tacit knowledge from one person to another;
- Externalization: Translate tacit knowledge into explicit knowledge in a repository ;
- Combination: Combine different bodies of explicit knowledge to create new explicit knowledge;
- Internalization: Extract the explicit knowledge from a repository that is relevant to a particular person's needs and deliver it to that person where it is translated into tacit knowledge ;
- Cognition: Apply tacit knowledge to a business problem⁹.

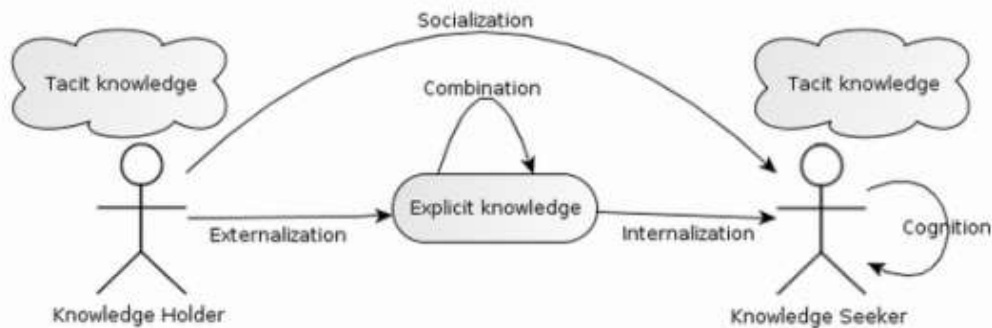


Fig. 2. Knowledge management phases⁸.

Except for the cognition phase, many different information technologies can be used to facilitate the other four knowledge management phases.

As the authors previously mentioned, the main difference between KM and e-learning processes is managed knowledge. In one case a company's knowledge is managed, in the other case the object being managed is the public knowledge of students. But there is a difference between ultimate goals of these two topics. The final goal of KM is to improve organizational performance such as encouraging innovation and enhancing customer value¹⁰. The ultimate goal of e-learning, on the other hand, is to enhance an individual's learning performance and efficiency¹¹.

Despite these different goals, the KM phases can be easily adapted to e-learning the process (see Fig. 3).

The socialization phase from KM can be applied to the collaborative e-learning process. In this process cooperation is provided between teachers and students: an instructor can teach a student by discussing an issue with the student directly, answering the student's questions, or letting students discuss it with each other.

The externalization phase is equal to the creation of new learning materials based on tacit knowledge about subject matters (e.g., developing lecture notes or writing articles).

Created learning materials as well as information from other resources⁸ must to be stored in a repository. It allows more students to access the learning materials at anytime from anywhere.

The combination phase in KM corresponds to the reorganization of learning materials to make course content more reusable and customizable.

And finally, students can directly retrieve online learning materials from the repository and transfer the explicit knowledge stored in the materials into their own understanding. This maps to the internalization phase in KM.

The illustration in Figure 3 clearly shows that an effective e-learning system demands the support of KM phases including socialization, externalization, combination, and internalization.

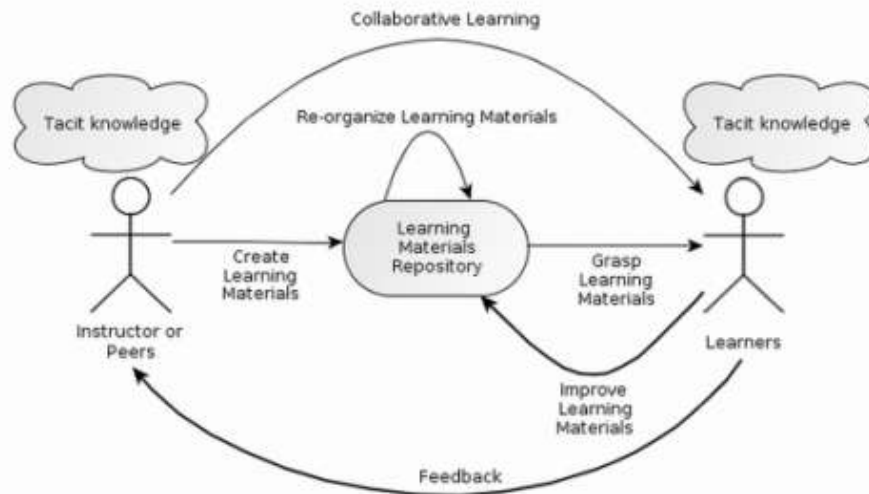


Fig. 3. Adapted KM phases for e-learning.

To customize KM phases to specific e-learning needs, the authors improved this framework by adding a feedback process and giving students the possibility to improve learning materials. These two updates are critically important to influence a student's motivation to learn and finish the started course, because the biggest problem of e-learning is students' lack of motivation.

In simple terms, the learning process can be described as a process of knowledge transfer from a teacher to the students. To realize the learning process it is very important to create valuable transferrable knowledge, therefore the next section discusses learning objects as the building blocks of the e-learning knowledge structure.

3. Learning objects: The building blocks of e-learning

In recent years, learning objects (LO) have gained a lot of interest as the basis of a new type of computer-based instruction in which the instructional content is created from individual components. This concept object has evolved from the need to reuse digital learning materials.

According to Wiley¹² the main idea of LOs is to break educational content down into small chunks so that they can be (re)used in various learning environments, in the spirit of object-oriented programming. LO is a self-contained component with associated metadata that allows the reuse of an object in different contexts.¹³ This object-based principle is based upon the idea that a course or lesson can be built from reusable instructional components which are created just once, but used several times separately in different contexts and modified to the user's needs.

The Learning Object Metadata Working Group of the IEEE Learning Technology Standards Committee (LTSC) refers to LOs as any entity, digital or non-digital, which can be used, re-used or referenced during technology enhanced learning¹⁴.

Wiley¹² developed the taxonomy of LOs and distributes five learning object types:

- Fundamental LO can be included as content, either as an image (JPEG, GIF or other, in medical education images play an important role!), a document (DOC, PDF, PPT, etc.), a movie (MPEG, AVI etc.); or any other file for example a simple text entry (containing only a literature reference to a hardcopy library book);
- Combined-closed LO, e.g. a video with accompanying audio;
- Combined-open LO, e.g. an (external) link to a web page, dynamically combining e.g. JPEG and QuickTime files together with Robson R. extraneously supplied textual material;
- Generative-presentation LO, for example, a JAVA applet;
- Generative-instructional LO, for example, an EXECUTE instructional transaction shell, which both instructs and provides practice for any type of procedure.

To create a qualitative LO they must correspond to at least the following four characteristics:

- Must be much shorter than traditional learning units, typically ranging from 2 minutes to 15 minutes;
- Must be self-containing: each learning object can be used independently;
- Must be tagged with metadata, which contains descriptive information allowing it to be easily found;
- Can be aggregated: learning objects can be grouped into larger collections of content, including traditional course structures¹³.

LO taxonomy and characteristics show, that it is possible to combine different types of materials and this makes it possible to personalize course content individually to each student's personal needs and perception without big time and money investments. The short period of time which a student needs to get acquainted with a LO made e-learning more accessible and allowed the realization of anytime-anywhere studies. And the reusability of LOs allows students to better understand learning materials and connections between different topics and courses. All these advantages of LO use can have a positive impact to student motivation.

LOs are stored in repositories. The idea of LO repositories is quite similar to the already well known database of learning materials, but there are some differences. These repositories provide indexing capabilities where users can add new LOs together with their metadata. LO repositories also offer some sort of searching or browsing feature to provide access to the content of the repository. There are two major types of such repositories: those containing both learning objects and learning object metadata, and those containing metadata only¹⁵.

An essential challenge for the e-learning community has been how to represent online learning material in a standardized manner to realize effortless interoperability and knowledge reuse¹⁶. In order to provide a unified description of the LO and its use in e-learning personalization, various metadata standards have been established. The next section describes some of the widely used.

4. Metadata standards

Metadata standards for the Internet are an attempt to bridge the gap between the comprehensive cataloguing which is done by professionals in the library context, and the free-for-all of document creation on the Web. In particular, these metadata standards allow creators of documents and managers of resource collections to describe resources in a detailed manner facilitating targeted queries by search engines¹⁷.

There are three main types of metadata:

- Descriptive metadata describes a resource for purposes such as discovery and identification. It can include elements such as title, abstract, author, and keywords.
- Structural metadata indicates how compound objects are put together, for example, how pages are ordered to form chapters.
- Administrative metadata provides information to help manage a resource, such as when and how it was created, file type and other technical information, and who can access it¹⁸.

In the context of e-learning, metadata is descriptive information about an LO. The best known metadata standard is Dublin Core. The original objective of the Dublin Core was to define a set of elements that could be used by authors to describe their own Web resources¹⁹. This standard is a well-accepted, but it is designed for any kind of knowledge resource and it does not provide specific features for the description of learning resources. Therefore, the e-learning industry is actively working on developing metadata standards for describing specific semantics of LO.

Some of the established standards include learning objects metadata (LOM) specification from the LTSC of the IEEE, Instructional Management Systems (IMS) initiated from National Learning Infrastructure Initiative of EDUCAUSE, and the Shared Content Object Reference Model (SCORM) specification from the Advanced Distributed Learning (ADL) Lab²⁰.

The most commonly used standard in e-learning systems is LOM. This standard was established as an extension of Dublin Core. LOM defines the minimal set of attributes to manage, locate, and evaluate a LO. All these elements are divided into nine categories¹⁸:

- The General - groups general information that describes the learning object as a whole;
- The Lifecycle - groups features related to the history and current state of this learning object and those who have affected this learning object during its evolution;
- The Meta-Metadata category - groups information about the metadata instance itself (rather than the learning object that the metadata instance describes);
- The Technical - groups the technical requirements and technical characteristics of the learning object;
- The Educational - groups the educational and pedagogic characteristics of the learning object;
- The Rights - groups the intellectual property rights and conditions of use for the learning object;
- The Relation - groups features that define the relationship between the learning object and other related learning objects;
- The Annotation - provides comments on the educational use of the learning object and provides information on when and by whom the comments were created;
- The Classification - describes this learning object in relation to a particular classification system.

Some elements of LOM will be used in the authors' future research to create a LO concept tree based on ontologies. Using metadata standards it is possible to describe a LO as a standardized set of attributes, but this information is not enough to explain the semantic links among different LOs. Ontologies allow to formally and explicitly specify the concepts that appear in a specific domain, their properties and their relationships. Therefore, the next section discusses the use of Semantic web and ontology in e-learning.

5. The use of ontology and semantic Web

An ontology may take a variety of forms, but necessarily it will include a vocabulary of terms, and some specification of their meaning. This includes definition and an indication of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretation of terms¹⁹.

In semantic modelling, ontology is represented by standardized languages such as RDF, RDFs or OWL²¹.

Stojanovic et al. proposes three different kinds of ontologies to form a new set of metadata to describe learning materials:

- Context ontology (e.g., concepts like "Introduction" and "Examples");
- Content ontology (e.g., "Data mining," "Machine learning," and "Neural networks");
- Structure ontology (the relations between learning materials such as "Previous_section," "Next_section," "IsBasedOn," and corresponding rules)²².

Ontologies are used to support semantic search, making it possible to query multiple repositories and discover associations between learning objects that are not directly understandable. This is impossible or very complex with simple keyword or metadata-based search supported by the current standards²³.

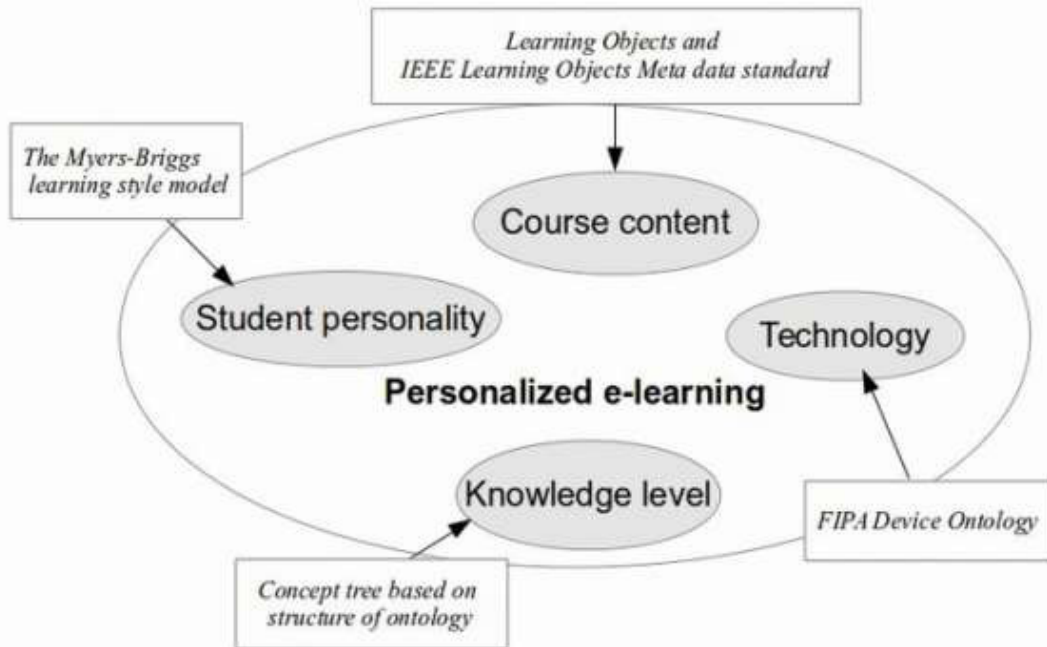


Fig. 4. The use of ontology in personalized e-learning.

On the other hand, the Semantic Web²⁴ promotes the next generation web in which contents are not only a huge collection of poorly structured information and services. The Semantic Web proposes the enrichment and reorganization of web documents and components by including explicit, semantic information. Such information has to be transparent for the user and computable by a machine.

Fig. 4 shows the potential use of ontology and semantic web in e-learning. In this research ontologies will be used to create a concept tree of learning objects and to detect the previous knowledge level and used technology. The concept of semantic web will be utilized to make the searching process faster, easier and more effective.

LOs will be described using metadata and some elements of the IEEE LOM standard. The standardized FIPA Device Ontology will be used for the description and characterization of used technologies.

FIPA Device Ontology specifies a frame-based structure to describe devices, and it is intended to facilitate agent communication for purposes such as content adaptation through terminal devices as PC's, PDA's and the like²⁵.

Applying and combining adapted KM phrases with contemporary data structuring and linking methods is possible to ensure a wide range of personalization for successful e-learning development.

6. Conclusion

The goal of this paper was to identify overlapping points between KM and e-learning phases to improve the structure and transfer of personalized course knowledge using effective methods of ontology and metadata standards. Clearly there are a lot of similarities between KM and e-learning processes, therefore it is possible to take the best practices from other research areas and include them in e-learning development. Nowadays it is very hard to separate just one scientific direction because more and more development is done in interdisciplinary scientific directions and old boundaries between scientific disciplines are breaking down.

Ontology-based metadata can describe the whole domain from different perspectives and support better description, searching and delivery of learning materials. By dividing learning materials into small pieces of semantically annotated learning objects, they can be easily customized by organizing learning objects based on the user's needs. This possibility is critically important for the personalization and customization of e-learning courses

in regard to a student's individual learning perception and understanding of course material as well as the device used.

With the ability to represent knowledge resource semantics and their relationships in a standardized format, the Semantic Web appears to be a promising technology for e-learning implementation.

Future work will be related to practical development of a personalized e-learning model using effective methods of ontology and a pilot project implementation in Vidzeme University of Applied sciences.

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