ARTICLE

Ontology for the User-Learner Profile Personalizes the Search Analysis of Online Learning Resources

The Case of Thematic Digital Universities

Marilou Kordahi

ABSTRACT

We hope to contribute to the field of research in information technology and digital libraries by analyzing the connections between Thematic Digital Universities and digital user-learner profiles. Thematic Digital Universities are similar to digital libraries, and focus on creating and indexing open educational resources, as well as improving learning in the information age. The digital user profile relates to the digital representation of a person's identity and characteristics. In this paper we present the design of an ontology for the digital User-Learner Profile (OntoULP) and its application program. OntoULP is used to structure a user-learner's digital profile. The application provides each user-learner with tailor-made analyses based on informational behaviors, needs, and preferences. We rely on an exploratory research approach and on methods of ontologies, user modeling, and semantic matching to design the OntoULP and its application program. Any user-learner could use the OntoULP and its application program.

INTRODUCTION

More online learning environments are supporting the creation and dissemination of quality Open Educational Resources (OER) to facilitate change in the education sector, improve education, ensure longlife learning, reduce cost, and other motives.[1] In 2002, the United Nations Educational, Scientific and Cultural Organization (UNESCO) recommended the definition of OER as follows: "the open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for non-commercial purposes."[2] The William and Flora Hewlett Foundation defined OER as "freely licensed, remixable learning resources—[They] offer a promising solution to the perennial challenge of delivering high levels of student learning at lower cost."[3] In 2012, UNESCO noted that OER offer education stakeholders an opportunity to access textbooks and other learning contents to enhance their knowledge and professional experiences.[4] Education stakeholders may choose OER based on their informational needs, behaviors, and preferences.[5]

We hope to contribute to the field of research in information technology and digital libraries by analyzing the connections between Thematic Digital Universities and digital user-learner profiles. We are conducting a case study using the Digital University Engineering and Technology.[6] In the following we will explain these topics and the interest in the Digital University Engineering and Technology.

In 2003, the French Ministry of Higher Education, Research, and Innovation initiated the creation of Thematic Digital Universities to facilitate the integration and use of information and

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communication technologies for education in university teaching practices.[7] In total, there are six Thematic Digital Universities which are organized by broad disciplines: health sciences and sports, engineering sciences, environment and sustainable development, humanities, economics and management, as well as technical studies. Thematic Digital Universities are similar to digital libraries, and focus on creating and indexing OER, as well as improving learning in the information age.[8] Although Thematic Digital libraries are mostly comprised of OER, they also develop complete training programs with some of these resources (e.g., Massive Open Online Courses, or MOOCs). They are partners with Canal-U, the video library for higher education, as well as the French national platform for Massive Open Online Courses (FUN-MOOC). Thematic Digital Universities are mostly created for learners and teachers, as they offer complementary educational resources to bachelor, masters, and doctoral programs.[9]

To date, learners and teachers have free access to most Thematic Digital Universities and corresponding educational resources. Registration is not required; however, without registration neither the learner nor the teacher can analyze her/his search for OER based on informational behaviors, needs, and preferences.[10]

We will focus on the analysis of OER metadata records in the context of Thematic Digital Universities. Each OER in the repository holds a metadata record to precisely describe its specifications to the learner or teacher (e.g., the learning level, language, and topics). Specifications are written according to the Institute of Electrical and Electronics Engineers (IEEE) standards for Learning Object Metadata (LOM),[11] LOMFR, and SupLOMFR. LOM provides an accurate descriptive schema of a learning object suitable for educational resources[12] (e.g., the classification and identification of an educational resource). LOMFR and SupLOMFR are currently applications of LOM in the French educational community.[13]

The Digital University Engineering and Technology attracted our attention because of the following characteristics: clear presentation of its objectives, regular information updates, priority for free access to OER and open data, 3,000 published educational resources, extensive documentation of OER indexing, interoperability of OER and metadata records, and an advanced search engine for OER. Each metadata record describes precise information on the OER, including the main title, keywords, descriptive text, educational types (or resources), learning level, copyrights, knowledge domains, topics, authors, and publishers. It is processed and structured with XML language which is human-readable and machine-readable.

Digital user profiles relate to the digital representation of a person's identity and characteristics.[14] Digital identity is the sum of digital traces (or "footprints") relating to an individual or a community found on the Web or in digital systems. Digital traces correspond to the user's profile, browsing history, and contribution actions.[15]

Our focus is the learner who wishes to use the Thematic Digital Universities for tailor-made analysis of retrieved information based on her/his needs and preferences. We offer the learner an option to register on these platforms to track behavior over time while searching for OER. Analyses are based on criteria the learner has previously chosen to personalize this search. Subsequently, we suggest using the term "digital user-learner profile." We will do our best to respect the General Data Protection Regulations when collecting information on the digital user-learner profile.[16] The General Data Protection Regulations are privacy laws drafted and passed by the European Union that prohibit the processing, storage, or sharing of certain types of information about individuals without their knowledge and consent.

The research questions are as follows:

1. In the context of Thematic Digital Universities, how can a user-learner personalize the search for open educational resources according to her/his digital profile?
2. In this same context, what kinds of information can a user-learner analyze in a search for open educational resources according to her/his digital profile?

The objectives of this article are to present the preliminary results of work in progress on the design of the ontology for the digital User-Learner Profile (OntoULP) and its application program, the Personalized modeling System for the User-Learner profile (PSUL). We rely on the methods of ontology,[17] user modeling,[18] and semantic matching.[19] The method of ontology is used to describe in a formal manner a set of concepts and objects which represent the meaning of an information system in a specific area and the relationships between these concepts and objects.[20] The method of user modeling describes the process of designing and changing a user's conceptual understanding. It is applied to customize and adjust systems to meet the user's needs and preferences. The method of semantic matching is used to identify and relate a meaning concept (or class) to its homologous concept in tree-like schemas and to consider the concept's position in these schemas (e.g., mapping a class in an ontology to homologous concepts in metadata records). This relationship can be a one-to-one concept or one-to-many concepts.

The OntoULP is a first approach, and it will be used to structure a user-learner's digital profile in the context of Thematic Digital Universities. We design this ontology for three main reasons: to structure collected and generated information[21] (e.g., structuring a user-learner's learning preferences will enable the identification of learning behaviors and activities), to analyze collected and generated information[22] (e.g., analyzing generated information by a user-learner may predict a search for OER), as well as to facilitate relationships between a user-learner and Thematic Digital Universities[23] (e.g., analyzing user-learner informational behaviors may improve OER creation and dissemination).

The PSUL will be designed as an application program for the OntoULP. It will be used to provide each user-learner with tailor-made analyses based on informational behaviors, needs, and preferences. PSUL will include a secure database and web pages, namely those for registering and editing the user-learner profile and its dashboard.[24] OntoULP and its application program will offer each registered user-learner an opportunity to analyze the search for OER according to informational behaviors and needs.

OntoULP and PSUL could be implemented in the structure of information systems for educational and research institutions, documentation and information centers, and many others. We will fine-tune our analysis by relying on a case example—the Thematic Digital Universities.

This article comprises six sections. First, we will explain the exploratory research carried out in the context of Thematic Digital Universities. Second, we will present the main published works related to the subject of the article. Third, we will explain the approach followed to design and write the OntoULP. Fourth, we will discuss the creation of the PSUL application program. Fifth, we will demonstrate the integration of the designed ontology and its application program into a mirror site to perform a technical test. Finally, we will discuss the completed work before concluding the article.

EXPLORATORY RESEARCH APPROACH

This exploratory research is based on an analysis of the literature, a semistructured questionnaire, and an in-depth documentary research. We check the consistency of collected information and identify the need to personalize the search for OER as well as make tailor-made analysis of information.

Methods used

During the first 18 months of the COVID-19 pandemic (November 2020–May 2021), we conducted qualitative research to deepen our comprehension of the practices of Thematic Digital Universities. We collected and interpreted primary and secondary information.

Primary information: We contacted the Digital University Association and their six Thematic Digital Universities.[25] Because of their extensive expertise and robust knowledge in leading or managing Thematic Digital Universities, Directors and General Secretaries were chosen to self-administer an electronic semistructured questionnaire. We contacted seven individuals and received six responses. In this questionnaire, we asked about the following topics: the recent knowledge of Thematic Digital Universities, conditions of access to OER, metadata records indexing as well as user-learner's expectations. An example of the questionnaire is included in the appendix.

Secondary information: We analyzed a report by the French General Inspectorate of the National Education and Research Administration. We have also studied recently-published scientific articles by Anne Boyer (2011), Deborah Arnold (2018),[26] and Sihem Zghidi and Mokhtar Ben Henda (2020).

The results and findings will be explained in the following paragraphs.

Results of information collection

We have compared responses to the questionnaire and contents of published documents and articles.

For the Digital University in Health Sciences and Sports, "resources are mostly accessible to learners from member universities, through an identification system based on the university email address."[27] Only a few resources are open to the public. Otherwise, according to comments gathered from the other four digital universities and Digital University Association, "Thematic Digital Universities are part of global movements providing access to OER by promoting open access to knowledge."[28] They are an opportunity for learners to discover new disciplines and explore new areas.[29] In fact, "the process for indexing metadata records meets standards for education, such as LOM, LOMFR and SupLOMFR."[30] At present, there is no feedback on the use of Thematic Digital Universities platforms. In other words, "Thematic Digital Universities have no information about learners who view OER, because there is no login and password. This is done on purpose to make them as open as possible."[31] These platforms are considered as a means of self-training with quality assurance, as the documents have been produced and validated by higher education teachers. "Thematic Digital Universities provide a certain flexibility allowing learners to work when and where they want."[32]

Findings

Five Thematic Digital Universities and the Digital University Association responded to the semistructured questionnaire. Two Thematic Digital Universities can track user-learners' behaviors. These digital universities are related to the disciplines of health and sport in addition to technical studies. To date, four Thematic Digital Universities cannot track user-learners' interactions based on informational behaviors and preferences. OntoULP and its application program could be implemented in four Thematic Digital Universities, which are related to the disciplines of engineering sciences, environment and sustainable development, humanities, economics, and management.

LITERATURE REVIEW

To our best knowledge, published research works addressing this research subject are limited in the context of Thematic Digital Universities.[33] We analyze the most recent ontologies and user modeling systems that are close to our research objectives. The main works we use are those of Bloom et al. (1984),[34] Smythe et al. (2001),[35] Green and Panzer (2009),[36] and Kordahi (2020),[37] in addition to Kelly and Belkin (2002). The work methods and field studies these researchers have developed are useful to design the structure of the OntoULP and the model of its application program. In the following paragraphs, we will explain these works and the relationships with this research article.

Selection of recently published works

In 2020 and 2021, Kordahi designed an ontology and a personalized dashboard for user-learners.[38] The objectives of these works were to track individual searches for OER and compare them with a user-learner's field of work. To design her ontology, Kordahi relied on standardized ontologies and validated taxonomies which are used in online learning environments, namely the IMS Learner Information Profile (IMS LIP)[39] and Bloom's Taxonomy. The personalized dashboard was linked to the user-learner ontology. The designed dashboard was tested technically with its ontology in a digital library environment to examine its performance. Kordahi used the methods of ontologies and semantic matching.

Learner model

We are mostly interested in the learner model[40] as it "is a model of the knowledge, difficulties and misconceptions of the individual [learner]." [41] As students learn the educational resources they find, the learner model is updated to display their current progress. The model can continue to tailor students' interactions as they learn. There are several learner models, such as the IMS LIP.[42] We examine the IMS LIP, which is based on a standardized data model describing a learner's characteristics. It is mainly used to manage a student's learning history to discover her/his learning opportunities. IMS LIP is made from 11 categories that gather learning information: "the identification, goals, qualifications and licenses, activity, interest, competency, accessibility, transcript, affiliation, security, and relationships."[43] This model has been successfully used by many renowned researchers (e.g., Paquette 2010[44]) to design a learner model and then adapt it to appropriate contexts.

IMS LIP's reliability, accuracy, and flexibility match well with the OntoULP motives. We will use it to begin designing the structure of the OntoULP and adapt it to the Thematic Digital Universities context. We will also consider the IEEE LOM, LOMFR, and SupLOMFR classification fields. This measure will be used to improve semantic matching between the OntoULP and OER metadata records.

Taxonomy of educational objectives

We examine the user-learner's educational objectives to meet informational needs and expectations.[45] In each OER metadata record, educational objectives are defined based on Bloom's Taxonomy (e.g., "understand the context and rules of scientific publication"[46]). Bloom et al. have developed a taxonomy for educational objectives to classify statements teachers expected students to learn as a result of lessons and instructions. The researchers described a method for allowing students to achieve educational goals while carrying out exercises utilizing the resources of the environment. Bloom et al. relied on in-depth qualitative studies to design and validate this taxonomy. Bloom's Taxonomy contains the following six major categories related to the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. This taxonomy was revised in 2001 by Lorin Anderson et al.[47] Bloom's Taxonomy is still in use internationally as in the works of Kordahi.

Integrating Bloom's Taxonomy into the OntoULP will enhance the structure of a user-learner's educational objectives. These educational objectives will be organized in six categories allowing the user-learner to refine her/his informational goals. Therefore, we will create a mutual link between the user-learner's educational objectives and OER educational objectives.

Knowledge domains

Knowledge organization systems[48] are seen as a valuable component for searching for OER.[49] Our research includes analyses of OER metadata records to establish relationships between their knowledge topics and the user-learner's topics of interest. In the Thematic Digital Universities' metadata records, a precise classification is reported respecting both knowledge topics and Dewey Decimal Classification (e.g., geographic information systems (526.028 5)).[50] The *Dewey Decimal Classification and Relative Index* 22nd edition,[51] published in 2003 by the Online Computer Library Center,[52] is being used worldwide in digital libraries and by the Thematic Digital Universities.[53]

In their works published in 2009, Green and Panzer have developed an ontology to structure knowledge domains.[54] This ontology recognizes two classes, which are Dewey classes and knowledge topics. We selected the Dewey Decimal Classification for the OntoULP because the Thematic Digital Universities are already using it. We will rely on Green and Panzer's ontology to structure the knowledge domains in the OntoULP (e.g., the use of Dewey classes and knowledge topics). We will establish relationships between the knowledge domains and user-learner model, allowing the user-learner to choose the most appropriate learning topics.

User modeling system

The "user modeling system for personalized interaction and tailored retrieval" is useful for analyzing each user-learner's informational needs and preferences.[55] Kelly and Belkin's system helps the user to track informational needs over time. It contains three classes of models and a set of interactions. The "general behavioral model" tracks information seeking and user behavior to determine informational needs. The "personal behavioral model" characterizes each user's information search according to specific preferences and behaviors. The "topical models" are associated with concepts related to each user's informational behaviors.

This model is developed by renowned researchers specialized in information retrieval and corresponds to the objectives of the research article. We will use the structure of Kelly and Belkin's model (2002) to design the PSUL application program, in the context of Thematic Digital

Universities. Relationships between both the PSUL and OntoULP ontology will be established to carry out personalized analyses of OER search.

ONTOULP ONTOLOGY

OntoULP's design is based on the works discussed in the previous section. It consists of two stages. We start by writing it. We then describe the ontology and emphasize the relationships between different entities.

Writing the ontology

We write OntoULP with Protégé Editor and use the HermiT inference engine to check the consistency of classes and their relationships with objects. The ontology's first approach is saved in OWL format, which is compliant with the Semantic Web technologies.

OntoULP description

The ontology is comprised of five subsystems. These are: user-learner, user-learner model, educational objectives, learning design, and knowledge domains. Each subsystem is composed of classes that inherit the attributes of the subsystem on which they depend. For brevity, the figures show the hierarchical representation of these subsystems.

The user-learner subsystem contains all recorded private information on the digital user-learner profile. The classes *personal information*, *identification sessions*, and *traces* provide information about the user-learner's behavior and search history for OER, e.g., the search duration for OER (see fig. 1).

The user-learner model subsystem is responsible for structuring collected information related to learning behaviors and needs, namely the classes *identification*, *interest*, *learning level* (or qualifications and licenses), *personal preferences* (or accessibility), *activities*, *learning objectives* (or goals), *affiliation*, and *network of contacts* (or relationships). In the context of Thematic Digital Universities, the resulting subsystem is composed of eight classes instead of eleven. The user-learner model subsystem conveys the structured information to the user-learner subsystem. Figure 1 shows the structure of both subsystems, the user-learner and user-learner model.

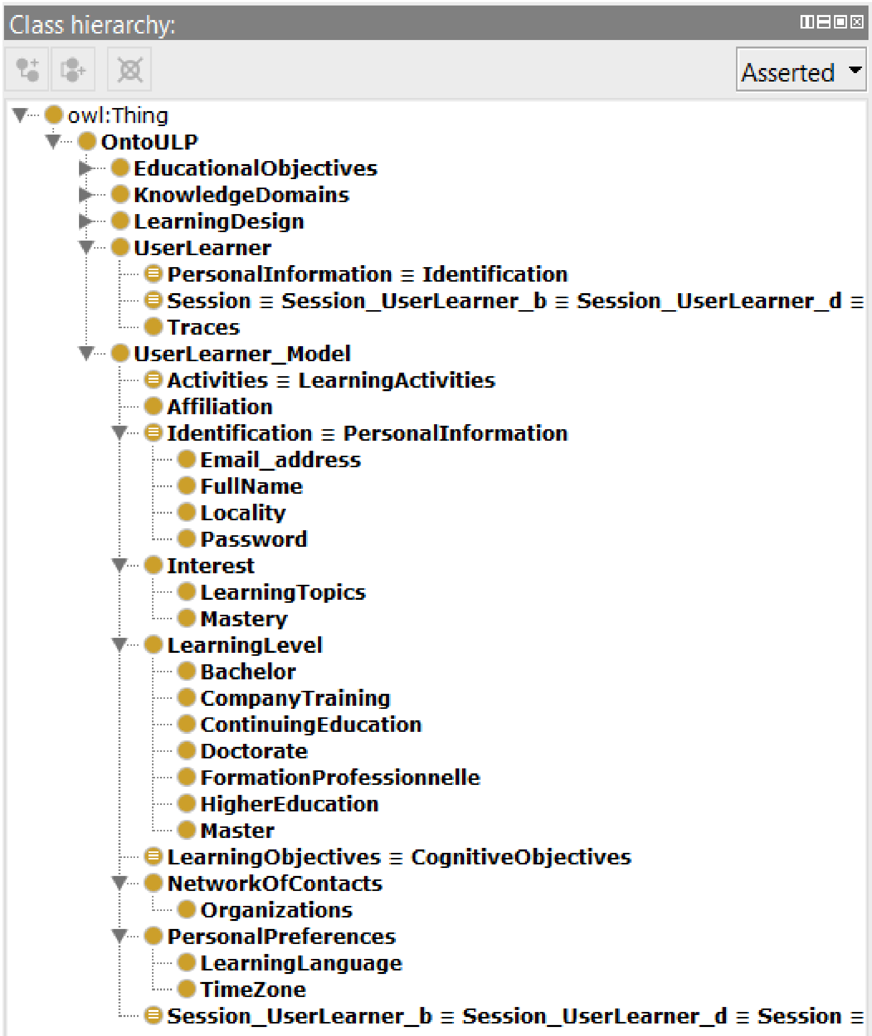

Figure 1. Hierarchical representation of both subsystems, the user-learner and user-learner model.

The educational objectives subsystem includes cognitive objectives involved in the process of acquiring knowledge. We design their structure by adapting Bloom's Taxonomy. The *cognitive objectives* class includes six interrelated subclasses: *remember* (or knowledge), *understand* (or comprehension), *apply* (or application), *analyze* (or analysis), *synthetize* (or synthesis), and *evaluate* (or evaluation). The *cognitive objectives* class is enhanced with the IEEE LOM, LOMFR, and SupLOMFR classification fields enabling the user-learner to choose objectives which best describe their needs and preferences, e.g., the class *apply* has subclasses *design, choose* (see fig. 2).

Figure 2. Hierarchical representation of educational objectives and learning design subsystems.

The learning design subsystem is an adaptation of the IMS Learning Design model, in the context of Thematic Digital Universities.[56] The learning design subsystem has two main classes: the user-learner's *environment* and *learning activities*. The *environment* class has six Thematic Digital Universities as subclasses. In a general manner, information about the *environment* class comes from Thematic Digital Universities platforms (e.g., the viewed metadata records). The *learning activities* class has *resources* as a subclass. The *resources* subclass is also enriched with the IEEE LOM, LOMFR, and SupLOMFR classification fields to complete its structure and meet the user-learner's needs and expectations. Further, we have connected the *learning activities* with *cognitive objectives* classes to ensure continuity between them (e.g., the subclass *experimentation* is associated with subclass *analyze*). Figure 2 illustrates the main structure of both subsystems, the learning objectives and learning design.

The knowledge domains subsystem contains the main class *Dewey Decimal Classification* and class *contacts*. This main class has two subclasses: *Dewey classes,* with the corresponding *divisions* as subclasses, and *knowledge topics,* with the corresponding *subtopics* as subclasses (e.g., *Science topic* corresponds to *Dewey class 500*, *Manufacturing subtopic* corresponds to *division 670*).

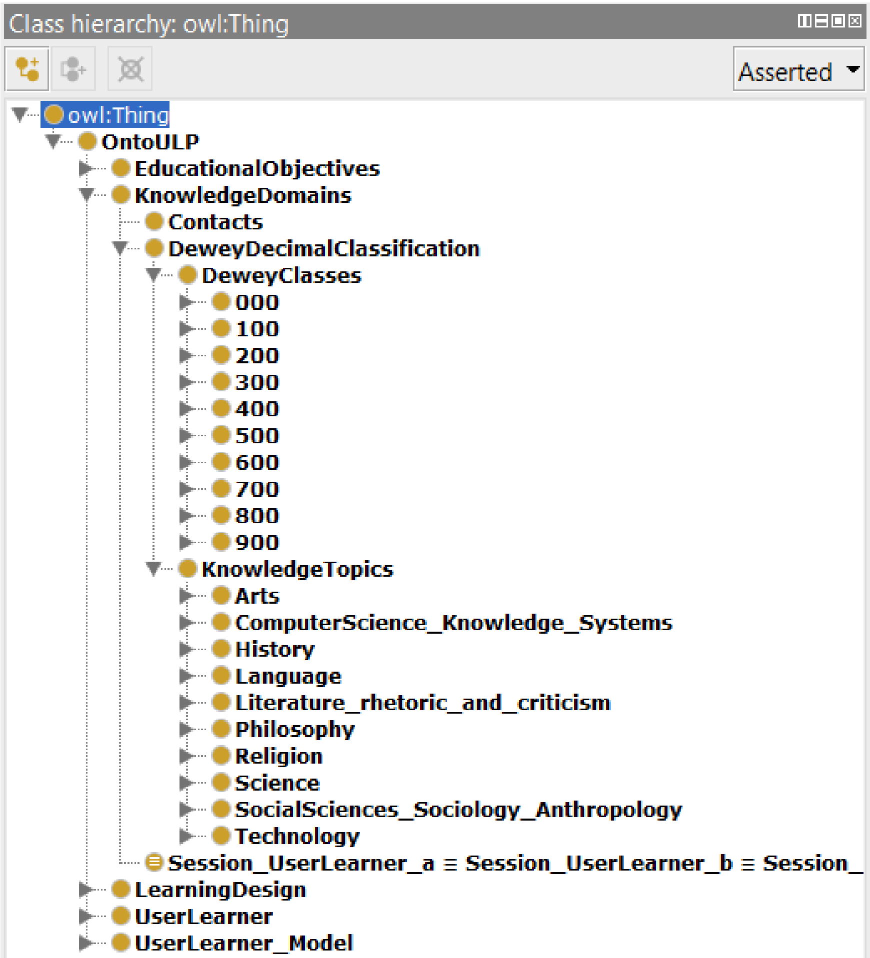

Figure 3. Hierarchical representation of the subsystem knowledge domains.

The subclass *knowledge topics* is related to the subclass *user-learner's learning topics* to improve informational behavior analyses. The class *contacts* is linked to the subclass *user-learner's network of contacts* to analyze the strength or weakness of networks between the user-learner and OER publishers/authors (see fig. 1).

The subsystem knowledge domains can deal with questions which belong to different levels in the OntoULP. For example, which learning topics is the user-learner looking for? Which network of contacts is the user-learner interested in? What are the activities related to the user-learner learning topics? What keywords searched relate to the user-learner's learning topics?[57] In Figure 3, we show some of the subsystem's elements.

PERSONALIZED MODELING SYSTEM FOR THE USER-LEARNER PROFILE

The PSUL is based on the works discussed in the previous sections. It is written with PHP, JavaScript, and XML, computing languages for the Web. This new modeling system comprises three classes of models: the general behavioral, personal behavioral, and topical (see fig. 4).

The general behavioral model has two roles. It registers a user-learner's digital profile in order to determine informational needs and preferences for OER. It also collects informational behaviors of a user-learner while viewing OER metadata records for tailor-made analyses. The general behavioral model includes the ontology OntoULP as well as user-learner registration and editing pages. The registration page contains relevant information about a user-learner, an option to accept or reject data collection, and a list of choices for behavioral analyses. Once registered, the user-learner can modify her/his profile from the editing page. Both pages are mapped to the OntoULP to populate criteria fields. The user-learner profile information is stored in a secure database (as described in the introduction).

The personal behavioral model is used to analyze information according to the registered digital user-learner profile and informational behaviors. It contains a set of queries to collect and tailor information for each user-learner. The sources of information are the general behavioral model and OER metadata records. This model is designed based on analyses of the general behavioral model. When a user-learner begins searching for OER, the general behavioral model provides the personal behavioral model with all profile information as well as the history of OER search. This information is transmitted to make an adjustment to the personalized user-learner profile. The user-learner profile changes as the personal behavioral model receives more information from the general behavioral model. Informational interactions connect the personal behavioral model to topical models.

The topical models bring together all analyses of OER search for each user-learner.[58] They are inferred from the personal behavioral model. Informational interactions connect the topical models to the general behavioral model. For now, we have designed four topical models and present their outcome in the user-learner dashboard page. This page may be used as a practical dashboard providing feedback to each user-learner, who can use these analyses to adjust or make changes in the profile or the OER search.

Topical model 1 is used to synthesize each user-learner's search history and to suggest a profile adjustment. The suggested adjustment is based on analyses of user-learner behavioral trends.[59]

Topical model 2 allows each user-learner to examine the list of knowledge topics which have caught her/his attention. It contains two separate lists describing viewed OER metadata records and matching them to the chosen topics of interest.

Topical model 3 shows comparative analyses between the user-learner's preference criteria and viewed metadata records. The user-learner can interact with this model by comparing the chosen topics of interest to the viewed knowledge topics. The user-learner can also compare the chosen learning activities to the viewed teaching pedagogies. The teaching pedagogies as well as knowledge topics are extracted from OER metadata records (see fig. 5a).

Topical model 4 highlights each user-learner's interest based on the keyword search volume. The user-learner can interact with this model by studying the relationships between searched keywords and chosen topics of interest (see fig. 5a and fig. 5b). Figure 4 shows the diagram of PSUL as explained in the paragraph.

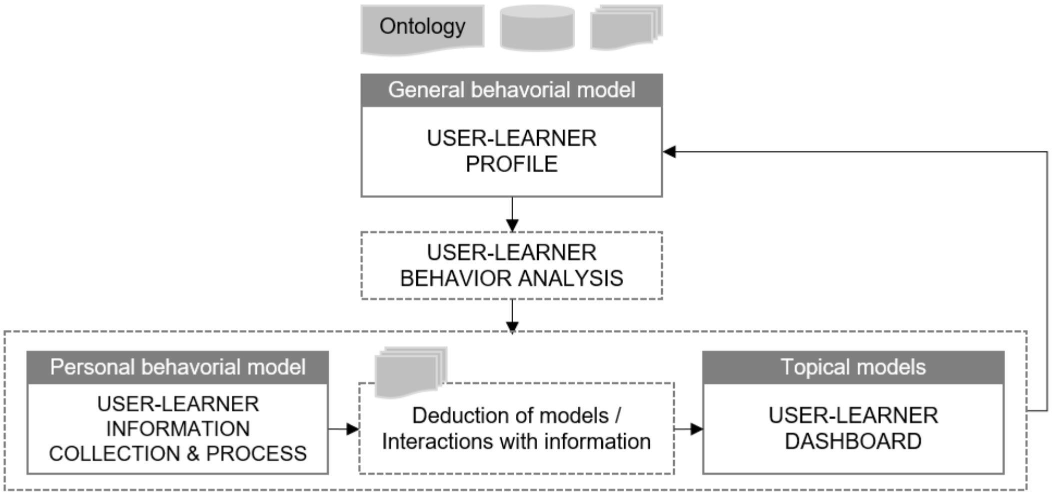

Figure 4. The PSUL diagram based on the Kelly and Belkin's system (2002).[60]

ONTOULP AND ITS MODELING SYSTEM IN THE CONTEXT OF A THEMATIC DIGITAL UNIVERSITY

For now, OntoULP and its application program are implemented in the Digital University Engineering and Technology private platform which is hosted on a private server. We conducted a technical test to mainly assess OntoULP's precision and performance.

The digital university's team has sent us a complete archive of their OER metadata records. These OER metadata records are saved on the private server with the Digital University Engineering and Technology platform. Once a user-learner is registered to this platform, she/he can carry out actions through the PSUL. For example, these actions are a search by keyword, personalization of profile, tailored-made analysis of OER search, and visualization of analyses in the dashboard.

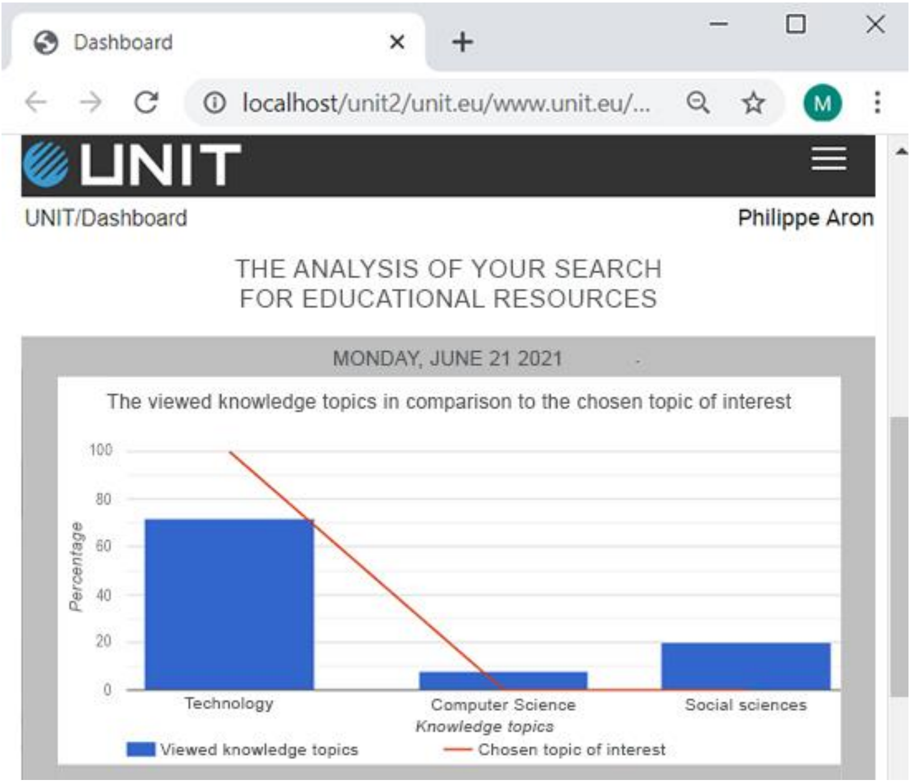

Figure 5a. Screenshot of a section of the dashboard. The bar chart shows comparative analyses between a user-learner's topic of interest and knowledge topics. The knowledge topics are extracted from the viewed OER metadata records.

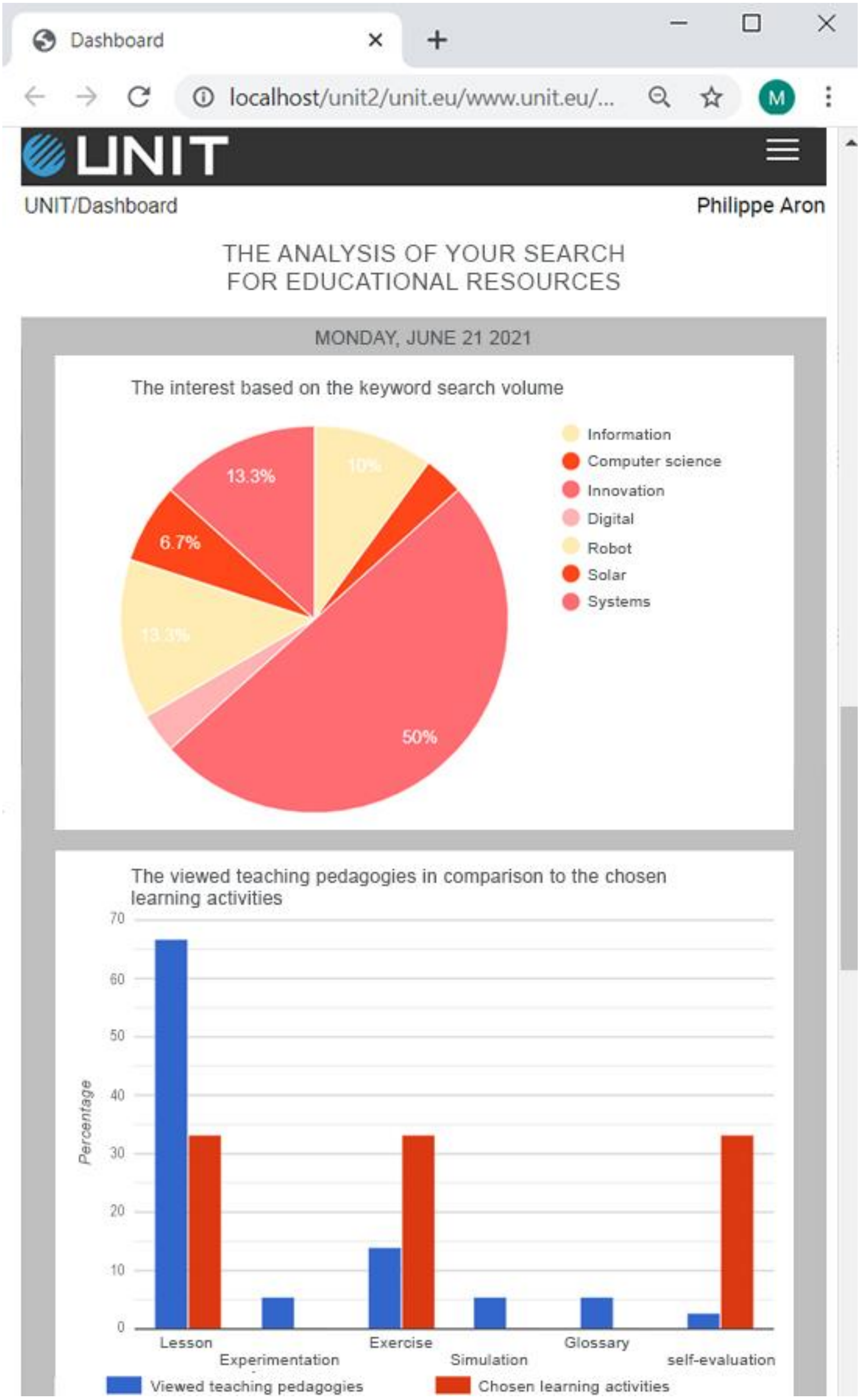

Figure 5b. Screenshot of a section of the dashboard. The pie chart highlights a user-learner's interest based on a keyword search volume. The bar chart shows comparative analyses between a user-learner learning activities and viewed teaching pedagogies. The keywords are extracted from the search. The teaching pedagogies are extracted from OER metadata records**.**

To avoid making the article longer, in figures 5a and 5b, we show brief results of a technical test. In this example, the user-learner's identity is fictitious, or the user-learner's persona is a construct.[61]

In other words, the user-learner's identity is not real, it is fabricated to conduct and complete the technical test. When registering, this user-learner has selected the *technology* topic (Dewey class 600) in addition to the *management and public relations* subtopic (Dewey division 650). This user-learner has also selected all topical models. During a viewing session, this user-learner chose to search for OER while using a few keywords. The keywords were chosen according to the user-learner's profile and in order to continue the technical test.

DISCUSSION AND CONCLUSION

The ontology for the digital User-Learner Profile is a first approach based on the Semantic Web. It is designed for the personalization of interactions and retrieval of tailored information. We have combined standardized and validated resources, such as the IMS LIP, Bloom's Taxonomy, and knowledge domains ontology, to allow the user-learner's search analyses.

We have discussed the design of a new application program prototype allowing a user-learner to analyze the search for OER according to her/his digital profile. PSUL provides automated real-time feedback based on the user-learner's search history and information she/he has inserted about herself/himself. We have then demonstrated the integration of the OntoULP and PSUL into a mirror site to perform a technical test.

The ontology's main characteristics are flexibility and adaptability. While designing OntoULP, we have reused or restructured resources to allow its use in other Thematic Digital Universities and online learning environments, including digital libraries. Another advantage of OntoULP is the application of several information processing techniques. For example, a registered user-learner can self-assess her/his search for OER by keywords. She/he can also analyze the relevance of the search for OER through the PSUL.

We have successfully overcome three essential limitations. The first limitation concerns the literature on the subject (see Literature review section). While contributing to the field of research in information technology and digital libraries, this work has also drawn on disciplines as diverse as those of education as well as cognitive, social, and human sciences. The terminological definitions of disciplines, concepts, and even methods vary over decades or centuries, and among groups of researchers. We have made every effort to define the different terms correctly and to cite the corresponding researchers. The second difficulty relates to the design of OntoULP. Published works dealing with this topic are rare. We used an exploratory research approach and the published works of renowned international researchers to fine-tune our study (see the Exploratory research approach and Literature review sections). We then determined the classes and objects as well as relationships between them. The third constraint concerns the design of the PSUL by following the Thematic Digital Universities policies and respecting the General Data Protection Regulations. According to the regulations, we have opted for an optional registration to Thematic Digital Universities and to collecting information on the digital user-learner profile. Thus, the user-learner will always have the possibility of registering to these platforms to make a tailor-made information analysis according to the digital profile.

As we conclude our work, we have a plan to focus our research and initiatives in the following areas. Firstly, we will further deepen our study of OntoULP classes to further increase their precision. We will also examine the search personalization of OER based on uses and practices of algorithms in the OntoULP.[62] For example, by relying on newer version of the ontology we will identify the topics of interest, which may interest a specific user-learner. We will implement this newer version in some Thematic Digital Universities to perform technical tests. Secondly, we will conduct qualitative and quantitative studies to analyze participants' behavior while using OntoULP and its application program, in the context of Thematic Digital Universities. For example, we will examine how many participants would choose to use the OntoULP and PSUL as well as how many wouldn't (e.g., the usefulness of ontologies to participants). We will analyze the behavior of individuals with digital personae and make connections between their searches for OER.[63] We will study their profiles, behaviors, and interests to ultimately suggest OER (e.g., the use of recommendation systems). We will also analyze how participants' behavior and feedback may affect future findings. Participants would be previously selected to contribute to these studies. Thirdly, we will study the effects of OntoULP and PSUL practices on the Thematic Digital Universities. This study will concern an analysis of the Thematic Digital Universities' search engines and users-learners' needs. For example, exploratory research will allow us to better understand user-learners' informational needs and expectations when using the OER search engines. We will analyze the design of OER search engines considering these informational needs and expectations. We will then utilize and integrate these findings to suggest alternatives to the Thematic Digital Universities to further improve these search engines.

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APPENDIX: SEMISTRUCTURED QUESTIONNAIRE EXAMPLE

Email subject: Digital University Engineering and Technology

Dear Sir, Madam,

I am affiliated to the Paragraph research laboratory at the Paris 8 University (*Laboratoire de recherche Paragraphe*, *Université Paris 8*).

I am writing to you to gather further information concerning the Digital University Engineering and Technology. The objective of the semistructured questionnaire is to deepen my comprehension of the practices of Digital University Engineering and Technology in order to write a research article and contribute to its improvement.

I would be grateful if you could answer the following questions:

- What are your responsibilities at the Digital University Engineering and Technology?
- Do the Thematic Digital Universities as well as Digital University Engineering and Technology provide "open" educational resources?
- Are the educational resources accessible only to students enrolled in the training programs of partner universities?
- How is the access to educational resources made?
- Do the educational resources follow document processing for their indexing?
- Is the document processing specific to the Thematic Digital Universities?
- What are the expectations of "users" searching for educational resources?

Thank you in anticipation

Sincerely yours,

Marilou Kordahi

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