

# Wayfinding Services for Open Educational Practices

M. Kalz, H. Drachler, J. van Bruggen, H. Hummel and R. Koper

Open University of the Netherlands/Educational Technology Expertise Center, Heerlen, The Netherlands

**Abstract**—To choose suitable resources for personal competence development in the vast amount of open educational resources is a challenging task for a learner. Starting with a needs analysis of lifelong learners and learning designers we introduce two wayfinding services that are currently researched and developed in the framework of the Integrated Project TENCompetence. Then we discuss the role of these services to support learners in finding and selecting open educational resources and finally we give an outlook on future research.

**Index Terms**—navigation, positioning, collaborative filtering, latent semantic analysis, open educational resources.

## I. INTRODUCTION

The role of content for technology-enhanced learning has been attributed a lower priority from several recently stressed theories and models of learning like socio-constructivist theories [1], situated cognition [2] or constructionism [3]. In addition the role of user-generated content is currently intensively discussed with its impact and importance on learning and competence development [4]. Nonetheless, learning content is still an important factor for technology-enhanced learning and a huge amount of learning content is critical to allow a wide-scale diffusion of self-directed lifelong-learning for the individual.

In the past several initiatives have been started to offer learning resources on a wide-scale on the internet for free. One of the first and most successful initiatives was the OpenCourseware project from the Massachusetts Institute of Technology in which the content from 1550 courses has been made publicly available. Several initiatives followed and initiated a new discussion about openness and access to learning resources in education. The UNESCO summarizes these new development 2002 in their Forum on the Impact of Open Courseware for Higher Education in Developing Countries as "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" [5].

Although the availability of open educational resources is currently increasing there is a lack between the mere availability of these resources and the educational use of the available material. To fill this gap it is important "how educational repositories of Open Educational Resources, which often want to grow based on user contributions and sharing among users, will manage to become more useful for communities of practice" [6]. The increase of open access and the publication of open educational resources

do not imply the creative use of these resources for learning.

This paper presents two services that are currently developed in the framework of the European Integrated project TENCompetence. These services deal with a similar problem that user of open educational resources are facing. The next part of the paper deals with user requirements and existing technological solutions to improve the competence and learning related search and use of open educational resources. Then we present positioning and navigation as two independent but connected services that can help learners to decide about which learning activity or resource to choose as next step in their personal competence development. Finally, we discuss the (dis)advantages and give an outlook about future research.

## II. SUPPORTING LEARNERS AND LEARNING DESIGNERS TO FIND SUITABLE OER

The main users for open educational resources are self-directed learners on the one hand and learning designers on the other hand. Both groups have specific requirements for using open educational resources for learning or developing learning opportunities. First of all, learners need to have orientation to choose the best suited learning activities from the vast amount of available resources. The label "best-suited" implies several options regarding the choice of material. In general the best suited resources for learners are the ones that help them to reach the "zone of proximal development" [7] regarding their competence development goals. This zone can be identified through an analysis of the learners' prior knowledge, his topical interest and/or a comparison to the next steps similar learners have taken.

For learning designers it is important to know which resources can be combined to produce a sound competence development program for learners. Again, there are several aspects for learning designers to decide about the appropriateness of open educational resources for constructing learning activities and courses. They have to address their target group based on specific characteristics like prior knowledge, learning goal, study time or preferred study style. Therefore, the most important problem for both user groups is an individualized search facility tailored to their needs and competence development targets. This search-and-find problem can be addressed on several levels: On the level of the learning objects, on the level of the technology for storing the objects (the repository level) and on the user level:

**Learning Objects Level:** To unify the description of learning resources the IEEE LOM standard has been used in many repositories to describe the contained resources [8]. But the IEEE LOM standard has been criticized because of its limited possibilities to enrich learning objects with educational meaningful information [9]. In addition, research has shown that it is not recommendable to let authors enrich learning objects with metadata because this does not lead to sufficient quality of the metadata [10]. To ensure high qualitative metadata domain experts are needed who tag the resources with an agreed upon taxonomy of keywords. As an alternative to IEEE LOM several repositories use an extended set of the Dublin Core Standard [11]. This extended set offers more flexibility to enrich learning resources with educational and competence development related information but in essence the expert problem remains.

**Repository Level:** On the level of the learning object repositories the Open Archive Initiative Protocol for Metadata Harvesting (OAI PMH) was a first step towards pooling of resources from different origins [12]. Currently, the work on the Simple Query Interface (SQI) has enabled interoperability for search between multiple repositories [13]. This intra-repository specification allows users to find learning objects in several distributed repositories.

But solutions on the level of the object and the repository do not address the problem that the success of the search is still dependent to a large extent on the quality of the metadata attached to the learning objects. Additional approaches on the user layer are needed to address the above described problem description for users of open educational resources. Especially when the search functions should address and support competence development the contribution of users is needed to add this information to the learning resources in open content repositories. These distributed resources are not only used in “formal learning environments” but also used by distributed self-directed learners who use them in a more informal way. Therefore, we imagine a mixed use of different OER repositories with additional user driven contents in future. Such an emerging OER environment requires highly automated services to support the learners and limit their level of maintenance as far as possible.

In the European Integrated Project TENCompetence we are currently researching ways to personalize distributed learning resources, units of learning and competence development programs in Learning Networks (LN) [14]. In LNs learners, team, or institution are free to add any kind of content they want to. Thus, LNs could consist of different mixed OER, formal learning offers, or separated learner contributions at the same time.

Two wayfinding services on the user level are responsible to offer individualized competence development programs in LNs. Wayfinding services should tell learners where they currently stand in a chosen competence development program and which way they should choose to foster competence building in a learning network. The positioning service analyzes the prior learning of learners through a content analysis method while the navigation service recommends the next best learning activity for a student. In this contribution we introduce these services and discuss their potential as a bridge from distributed open educational resources to open educational practices.

### III. TENCOMPETENCE WAYFINDING APPROACH

To provide learners with orientation for their competence development our research focus is to answer the following questions: Where do I stand in the “curriculum” and which step should be next to reach my personal learning goal? To answer this question we have conducted research how to support this orientation process with technology. Two services have been recently implemented and tested in the framework of the TENCompetence project: A positioning service uses language technology for prior learning assessment while a navigation service applies research from recommender systems to help learners to find orientation.

#### A. Positioning

Especially from the perspective on lifelong learning it is an important question for learners where they should start their competence development on the basis of what they already know and what they want to achieve as competence development goal. In traditional educational settings this problem is addressed through the Accreditation of prior learning (APL) [15]. This process – which is most of the times carried out the submission phase of study programs in Higher Education – relies on domain experts who study the portfolios of learners and decide about exemptions for them. Due to the fact that this is impossible to follow this approach when people change their domains and institutions quite often during their life, we use language technology to support this process.

Our current project uses Latent Semantic Analysis (LSA) to support the APL process for technology enhanced learning. Latent Semantic Analysis (LSA), in the past sometimes referred to as Latent Semantic Indexing (LSI), is used to calculate a similarity between the learner documents and the learning resources. LSA is a theory and method for extracting and representing the contextual-usage meaning of words by statistical computations (16). The whole process of this analysis consists of several steps like the pre-processing of the text, some weighting and normalizing mechanisms, the construction of a term-document matrix and a mathematical function called singular-value decomposition (SVD), which is similar to factor-analysis. The end result of this process is a latent semantic space, in which the main concepts (or types) of the input are represented as vectors. Concepts in this space are similar if they appeared in the same context and so their vectors are close together in the space providing a measurement for the similarity of text. LSA is successfully applied in several research fields like informatics, psychology or medicine.

The most prominent example for the use of LSA in an educational environment is the assessment and feedback of free text in intelligent tutoring systems. Some examples of these applications are the Intelligent Essay Assessor (17), Summary Street (18) and Select-a-Kibitzer (19) to mention only a few. Some researchers have used LSA to provide students with appropriate texts that fit to their current knowledge [20,21].

Our application of LSA is similar but has a different motivation and context. We are using LSA to assess prior knowledge of learners for placement or positioning decisions and finally the construction of personalized learning paths through a learning network. A high

correlation between documents in the portfolio and learning resources leads to an exemption of this specific learning activity. The result of these analyses should be taken into account for the creation of a personalized learning path. Some learning activities on the way to the target competencies a learner wants to achieve may be exempted because of the results of this prior learning analysis. We conducted an expert validation of the positioning service and compared the results of LSA to results that experts have given. The first results of the service look promising.

**B. Navigation**

Navigational support is necessary for providing learners with appropriate learning resources when there is not a clear curriculum. We have recently designed a navigation service as a personal recommender system (PRS) for learning resources. The general concept of the PRS is in line with hybrid recommender systems in other domains. Hybrid recommender systems combine different kind of recommendation techniques to achieve a higher accuracy in their recommendation [22, 23, 24]. Every single recommendation technique has its own advantages and disadvantages. Thus, a combination of techniques in a hybrid recommender system can balance the advantages and disadvantages of single techniques through switching or cascading them in a recommendation strategy [26] to increase the overall accuracy of the recommendations. Figure 1 shows an example of a possible recommendation strategy that combines a stereotype filtering technique with an ontology based recommendation.

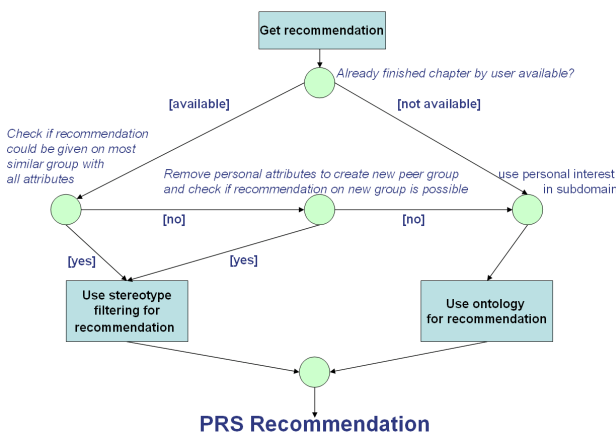


Figure 1: Combination of stereotype filtering and item based filtering in a recommendation strategy.

Recommendation strategies decide which specific recommendation technique provides the highest accuracy for the current user based on specific history information about users and items.

The following recommendation techniques are promising for recommendations in OER in order to have less maintenance and highest guidance for the learners 1: User-based collaborative filtering 2. Stereotype filtering and 3. Item-based filtering.

1. Collaborative filtering techniques (or social-based approaches) use the collective behaviour of all learners or learning resources. Both user- and item-based collaborative filtering use the same mechanism of correlation for different objects. To underline the

differences between these two techniques we now describe them together.

User-based filtering correlates users by mining their (shared) ratings, and then recommend new items that were preferred by similar users (see Figure 2). Similar users are calculated through shared preferences for learning resources.

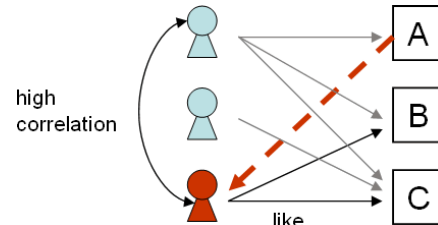


Figure 2: User-based collaborative filtering

2. Item-based techniques correlate items by mining (similar) ratings they own, and then recommend new, unknown but similar items to the learners (see Figure 3).

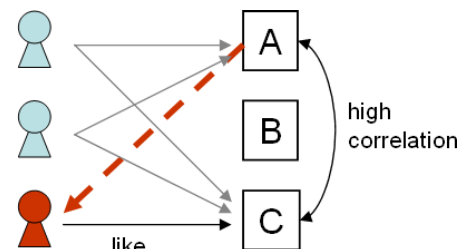


Figure 3: Item-based collaborative filtering

Main advantages of both techniques are that they use information provided bottom-up by user rating, that they are domain independent and require no content analysis, and that the quality of the recommendation increases over time [25]. User- and item-based techniques are useful for networks which are dealing with different topics like OER. They do not have to be adjusted for specific topics, which is important because we expect many LN for different topics. CF techniques can identify learning resources with high quality, allow learners to benefit from experiences of other, successful learners. CF techniques can be based on pedagogic rules that are part of the recommendation strategy. Characteristics of the current learner could be taken into account to allocate learners to groups (e.g., based on similar ratings) and to identify most suitable learning activities. For instance, suitable learning activities can be filtered by the entrance level that is required to study the learning activity. The prior knowledge level of the current learner would than be taken into account to identify the most suitable learning activity.

A disadvantage of both techniques is the so called 'cold-start' problem. It is due to the fact that CF techniques depend on sufficient historical user behavior data. Even when such techniques have been running for a while, adding new users or new items will suffer this problem. New users first will have to give a sufficient amount of ratings to items in order to get accurate recommendations based on user-based CF (new user problem). New items have to be used or rated from a adequate amount of users to be recommended (new item problem). To solve these disadvantages, user- and item-based CF have to be combined with other techniques, like Stereotype filtering, in a recommendation strategy.

3. Stereotype filtering techniques can recommend preferred items to similar users based on their mutual attributes (see Figure 4). They are also domain independent, but they do not require that much history data to provide recommendations. Therefore, it is useful to solve the ‘cold-start’ problem of User- and Item-based techniques. Additionally, stereotype filtering offers exploration through ‘serendipity’ what is less the case for user- or item-based filtering and an advantage for a combined recommendation strategy.

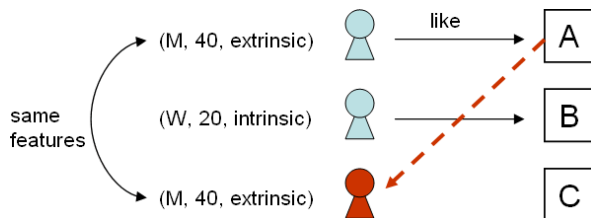


Figure 4: Stereotype filtering

The stereotype recommendation technique is an accurate way to allocate learners to groups if no behavior data is available. In combination with techniques that suffer from the ‘cold-start’ problem, stereotypes complement a recommendation strategy, enabling valuable recommendations from the very beginning.

Beside the general issue of selecting the most appropriated techniques for an environment, the domain of learning demands to be addressed by specific characteristics. For PRS in lifelong learning context it is not possible to simply take or adjust an existing PRS for consumer products (like in amazon.com). PRS for lifelong learning should support the efficient use of available resources to improve the competence development, taking into account the specific characteristics of learning. PRS have to be driven by pedagogical rules, which could be part of the recommendation strategy. The recommendation strategy looks for available data to decide on which technique(s) to select for which situation. The same situation is given when users are dealing with open educational resources for their personal competence development.

Our approach of navigation support was evaluated in a psychology pilot implementing the ISIS recommender system. This recommender system used an attribute-based recommendation technique in combination with an ontology based recommendation technique in a hybrid recommender system.

#### IV. SERVICES FOR OPEN EDUCATIONAL PRACTICES

In the TENCompetence project we are developing a Personal Competence Manager (PCM) that will support individuals in building competencies. One important feature of this application is the underlying theoretical approach of LNs. LNs should enable learners to develop their competencies together with peer-learners who have a similar competence development goal. Learners in LNs are able to develop their own learning paths including the use of openly available resources and learning activities. Since all users in the TENCompetence environment are able to share their learning paths and learning activities and resources they have used for competence building the environment should enable users to collect competence related information about open educational resources and educational/contextual metadata.

In addition, the above described positioning service can give a valuable contribution to help learners finding their way through open educational resources. Instead of using this service only for exemptions the similarity rate between a learner’s portfolio and documents in repositories can provide an individual “interestingness factor” for open educational resources. A high correlation between these resources and a portfolio can show that the learner already knows most of the concepts represented in these resources while a very low correlation would mean that these resources are completely out of the learners’ context. While the positioning service takes only into account individual information of learners the navigation services uses also information by other learners to provide a recommendation.

For OER several situations would lead to different recommendation strategies. Without user information only a recommendation strategy based on topics or ontologies is possible. If a network of learners who use the content from several distributed repositories can be established the user behavior can be taken into account to recommend best suited learning resources. Since the learner groups of open educational resources are already available there is a need for a technology that connects these distributed learners and helps them with their competence development.

#### V. DISCUSSION AND OUTLOOK

This paper has introduced positioning and navigation as two wayfinding services that haven been developed in the framework of the TENCompetence project. We believe that the combination of prior knowledge analysis and a personal recommender system has a high potential to bridge the gap between the distributed resources and distributed self-directed learners who have the burden to choose suited learning activities and resources. Both services have been recently analyzed in user studies and first results of these studies are promising. But this approach has also some issues: The use of Latent Semantic Analysis is limited to highly textual domains. In addition LSA can only find a similarity when the concepts used by the learners are represented in the semantic space. But there are several special presentation types (forms, descriptions of experimental designs etc.) that show an inherent higher prior learning than the purely textual content can show. In this case domain experts can deduct this but LSA cannot.

For the navigation service the use social based approaches like collaborative filtering techniques is limited by a number of disadvantages. New users first will have to give a sufficient amount of ratings to items in order to get accurate recommendations based on user-based CF (new user problem). New items have to be rated from a sufficient amount of users to be recommended (new item problem). Another disadvantage for CF techniques is the sparsity of past user actions in a network. Since these techniques are dealing with community driven information, they support popular taste stronger than unpopular. Learners with unusual taste may get less qualitative recommendations, and others are unlikely to be recommended unpopular items (of high quality).

In the future we will implement and test our services in several settings where open educational resources are used for competence development, specifically in the OpenER project of the Open University of the Netherlands where

learning resources from the Open University are published under an open content license. We are planning to setup a pilot with OER in a community space. Additionally, we will integrate the positioning and the navigation service to evaluate the support of these services for lifelong learners. The positioning service is planned to be used every time a new learner enters the community or a learner decided to study for a new learning goal. The positioning service uses the profile and historical information of learners to determine which learning resources are beneficial and which are not beneficial for their competence development.

The navigation service uses the outcome this calculation to recommend the most suitable learning resource to the learners. Therefore, it is based on a recommendation strategy that combines different kind of bottom-up collaborative filtering techniques in order to prioritize the available learning resources for the individual competence development.

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## AUTHORS

**M. Kalz** is a young researcher at the Educational Technology Expertise Centre of the Open University of the Netherlands, PO – Box 2960, 6401 DL Heerlen, The Netherlands (e-mail: [marco.kalz@ou.nl](mailto:marco.kalz@ou.nl)).

**H. Drachsler**, a young researcher at the Educational Technology Expertise Centre of the Open University of the Netherlands, PO – Box 2960, 6401 DL Heerlen, The Netherlands (e-mail: [hendrik.drachsler@ou.nl](mailto:hendrik.drachsler@ou.nl)).

**J. van Bruggen** is Associated Professor at the Educational Technology Expertise Centre of the Open University of the Netherlands, PO – Box 2960, 6401 DL Heerlen, The Netherlands (e-mail: [author@nrim.go.jp](mailto:author@nrim.go.jp)).

**H. Hummel** is Associated Professor at the Educational Technology Expertise Centre of the Open University of the Netherlands, PO – Box 2960, 6401 DL Heerlen, The Netherlands (e-mail: [hans.hummel@ou.nl](mailto:hans.hummel@ou.nl)).

**R. Koper** is Director of the Educational Technology Expertise Centre of the Open University of the Netherlands, PO – Box 2960, 6401 DL Heerlen, The Netherlands (e-mail: [rob.koper@ou.nl](mailto:rob.koper@ou.nl)).

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