Research and Development of a Positioning Service for Learning Networks for Lifelong Learning

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Abstract. Positioning in learning networks is a process that assists learners in finding a starting point and an efficient route through the network that will foster competence building. This contribution presents the rationale for the positioning project and provides an overview about methodological questions for the research and development of a positioning service for lifelong learning and a short outlook on objectives and expected results.

Recognition of Prior Learning for Learning Networks

Lifelong technology enhanced learning should support flexible ways to build competencies across institutions and different contexts. While most of the former e-learning models are built from an institutional perspective now the individual should stand in the centre of every effort in lifelong learning. The concept of learning networks addresses this problem and offers a framework to bridge the different contexts of current technology enhanced lifelong learning [1]. A learning network connects actors, humans as well as agents, institutions and learning resources. Information and communication technologies are used in such a way that the network self-organizes. The actors in the learning network share one common goal: furthering the development of competence by learners. Competence is defined here as effective performance in a domain at different levels of proficiency. Competencies include skills and they can be divided in 5 main competencies (cognitive, functional, personal, ethical and meta-competences) [2].
A traditional approach to overcome the limitations of institutional dependencies is the concept of Accreditation or Recognition of Prior Learning (APL/RPL) [3]. APL offers methods and techniques to identify prior learning experiences from formal and informal education. This procedure is especially important if a person crosses the boundaries between work and learning or between academic disciplines. Current practice in APL implements procedural solutions to the APL problem. These solutions stipulate the steps in a procedure in which the learner can present material to

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substantiate claims on particular exemptions. These claims are then evaluated on equivalence: has the learner substantiated the claim that s/he has acquired learning outcomes equivalent to those produced by the courses for which exemption is sought. Most of these APL methods rely on experts who study the learner profiles and decide which learning activities leading to a competence should be exempted and which ones are best suited as starting position for the student. But this way of positioning a learner is a very time-consuming and expensive approach. This project concentrates on computational approaches to address the positioning problem for lifelong learning and delivers techniques and tools that may help to clarify claims on equivalence thus bringing content-based analysis to the procedures of APL.

Research Question

The project concentrates on the following research question: Taking into account the goals and the history of a learner what is the best place for the learner to start and which activities should be exempted? To address this problem this project researches models to address the positioning problem and develop a prototypical solution useful for lifelong learners. The project will focus on the process of mapping competence information of learners to the competence information in learning networks. Since there are already (technical) solutions to present the individual situation of a learner like electronic portfolios and there are already many learning resources to support formal and informal learning there is a lack of research how these distributed parts of technology-enhanced lifelong learning can be connected. A positioning service helps learners to find the best entry position in learning networks according to his competence development goals. Conceptually it is important to stress that the positioning service should be seen as a recommender system for starting positions/exemptions but not as an automated system without human decisions. The service could be used either by the learner or by an expert who has to decide about exemptions. Since both sources of data (learner data & network data) can change very fast in an environment for lifelong learning a dynamical positioning service would have to redefine the learners' position every time a new competence related information has been added either to the learner profile or the learning network. The quality and success of a positioning service should be controlled through the criteria of reliability (the same situation leads to the same recommendation) as well as validity (the recommendation matches that of experts). The project will focus on the comparison of similar data for positioning. Three cases will be explored and addressed during the project: A content-based approach, an approach that additionally uses metadata for positioning and a third approach combining content, metadata and the use of competence ontologies and semantic-web technology.

State of the Art and existing solutions

From an educational perspective it is important for successful technology-enhanced learning to offer learners individualized learning experiences and educational

resources that fit to the needs and individual situation of the learners. The positioning service should reduce the time required to reach learning objectives based on an automated portfolio assessment. Previous work from user and learner modeling for the generation of possible routes and the selection of learning resources for tailored and individualized instruction also takes into account prior knowledge and goals. But there are no consistent models and techniques to assess the prior knowledge of learners.

The project will research the development of a web service to position learners in learning networks according to the competence development goals they want to achieve. Web services provide a standard means of interoperating between different software applications, running on a variety of platforms and/or frameworks. Different situations can be given for the comparison of the competence related information of the learner with competence related information in the learning network. To focus the research project it will be limited to three different cases to address the positioning problem. The project will cover only situations where similar data can be compared. The following figure shows the focus of the project.

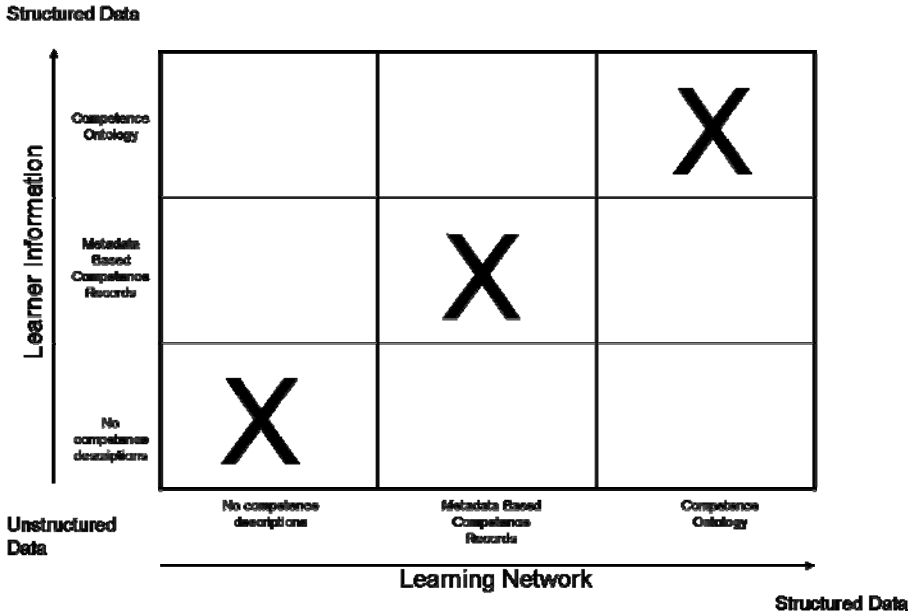

Fig. 1. Positioning Situations Matrix

In case one a positioning service has to handle a situation without any competence information in the learner profile and the learning network. This situation could occur when a learner does not already have an electronic portfolio and his learning network does not contain explicit competence related information but only learning activities and content. To approach this situation we make use of content analysis to compare the learner profiles and the learning activities in the learning network. We assume that there is a similarity of the contents of (learning) materials studied or produced by the student (source material) and the material contained in the learning activities in the

learning network (target). If a positioning service determines that the content of source and target materials overlap substantially, the target activity is exempted. In the content-based positioning service document similarity is computed using latent semantic analysis (LSA).

The second case deals with metadata-based competence related information in the learner profile and the learning network. There are different standardization efforts in the field of competence related metadata. Five standards and specifications deal with the competencies of the learner: The IMS Reusable Definition of Competency or Educational Objective (RDCEO) specification aims at a standard description of competencies and educational objectives for online and distributed learning. RDCEO is expected to promote common understanding of competencies that can be used in competency development (learning and career development) or in specifying learning pre-requisites or learning outcomes [4]. The RDCEO offers a unique identifier to assign an unstructured competency description to an object for example in a Unit-of-Learning (UoL). Based on the RDCEO a draft standard for Reusable Competency Definitions (RCD) is being defined in the IEEE. Although RCD does not intent to offer a solution to the aggregation of competencies from sub-competencies the data-model allows the integration of relational information or competence ontologies through embedding additional metadata [5]. For portfolios two specifications are of interest. The IMS Learner Information Package Specification (LIP) is designed to package learner information for the exchange of data [6].

The IMS ePortfolio specification builds on the LIP specification to ensure portability and exchange of ePortfolio records for learners [7]. The specification is addressing different usage possibilities (assessment, planning of learning) and it can store produced artifacts form the learner and formal achievement records like references. A slightly different approach comes from the HR-XML Consortium. The consortium develops a standard suite of XML-specifications to allow the exchange of Human-Resource-related data, such as a competency schema for a variety of business contexts that is applicable in recruitment processes [8]. The model allows the evaluation, rating and ranking of competences which are an important issue in recruiting processes. On the resource side it is important to mention that the IMS Learning Object Metadata (LOM) has no element to store competence related information at the moment [9]. They could be stored in the educational segment of the metadata as proposed in [10] but this does not seem to be a widely adopted solution to the problem. Nonetheless in case two of the positioning problem competence descriptions in these metadata could be used for positioning by mapping them and finding similarities between the descriptions. The research needs for this part of the positioning problem are the methods and techniques that can be applied to compare competence related metadata and use similarities in metadata for the positioning service.

The third case is the comparison of competence ontologies in the learner profile and the learning network. Ontologies are metadata schemas providing a controlled vocabulary of concepts and they can be useful to share common understanding in a domain in a machine-readable way. For competence development ontologies or taxonomies can be used to define competences related to competence development programs in the learning network. Competence ontologies could be either added to the learner profiles [11], learning objects [9] or the competence development programs [12]. But the design and implementation of competence ontologies is still a

very complex and time consuming task [13]. For competence similarity the number of different ontologies and the difference between vocabularies used is important. There are several models and techniques for measuring similarity of ontologies [14, 15]. As we may find competence ontologies in formal education it is very unlikely to find them in non-formal education. In an ideal situation every learning network could share a common understanding of the competences needed for successful running through the program based on ontologies. The ontologies in the programs could be added to the learner profiles step-by-step after they have successful finished the connected learning activities. In this case positioning could happen through the mapping of competence ontology inside the learner profile with the competence ontology in the learning network. The project will concentrate in this phase on the measurement of similarities for competence ontologies the use of this information for positioning.

Methodological Questions

Because of feasibility reasons we will concentrate on a situation from formal education where we will have predefined activities in the learning network. All experiments will be done in an introductory psychology learning network of the Open University of the Netherlands. In the beginning we will collect student data about their educational history and prior learning experiences. Besides plain information on their former courses we need also material or hints to material they have produced or studied in their former education. We will start to compare the content of the learner portfolios with the course content for case one. In the content-based approach document similarity is computed using latent semantic analysis (LSA).

LSA is a technique from natural language processing that was originated in the field of information retrieval [16]. LSA is based on word (co)-occurrences in documents, thus all order (syntax) of words or semantics in the original documents is ignored. All analyses are performed on a Term-by-Document matrix with word frequencies in the cells. The dimensions of this matrix are computed and the largest dimensions found (the semantic factors) are retained to reproduce the original matrix [17]. In the reproduced matrix each document is represented as a vector. The smaller the angle between two document vectors the higher they are correlated, that is, they are expected to contain materials that have substantial overlap. After the data collection we will build a corpus for each student and compare them through LSA to the content from the activities in the learning network.

The result will be a correlation between the data of the students and the activities in his chosen competence development program. To integrate also a self-estimation by the students we will ask them before and after every activity about their prior learning experiences according to the competences connected to the activities. By this means we can compare at the end (data interpretation) the results from the LSA engine to the results from the experts and the self-estimation by the students. The result of the experiment should lead to a model for content-based positioning in learning networks. To evaluate the results from the experiment we have to answer the following questions:

1. Is the recommendation valid?
   A valid positioning service should deliver recommendations that can be compared to human judgments. To control the validity of the recommendations from the positioning service the results will be compared to the results from two domain experts who should compare the learner profiles with the introductory psychology learning network. If they give a very similar recommendation after comparing the learner profiles and the activities in the learning network the positioning service delivers valid results.

2. Is the recommendation reliable?
   The reliability of the recommendation should be controlled through the repetition of the positioning with very similar situations. If the same situation delivers always the same results the positioning service and the delivered recommendation is valid.

3. Is the recommendation efficient?
   The efficiency of the service should be compared to the time and cost of domain experts. For this issue we need to know how long a domain expert would need to analyze the learner profile with the learning network. Another efficiency issue is the need of computing power for a positioning service. The efficiency of the positioning service can at a later stage of the project be compared in relation to given data. In the second experiment we will compare the efficiency of metadata-based positioning to the content-based approach. As a result we should know after the project about the data requirements for positioning.

4. Are the basic assumptions sound?
   For the evaluation of the basic assumptions for positioning we will compare the results of the experiments. For example the comparison of competence ontologies or competence maps should give a direct comparison of competences while we assume in our first experiment that the comparison of content can also give sufficient results for the accreditation of prior learning experiences in learning networks.

The second model will concentrate on the comparison of a combination of different metadata for positioning. The hypothesis of the experiment is that positioning recommendations can be based on metadata in the learner profiles and the content of a learning network and that these recommendations are comparable to those of experts. The aim of the model is to develop a solution for a positioning service if metadata are available in the learning network and the learner profiles. As a first step we will add metadata to the learner profiles and the activities from the introductory psychology learning network. For this part of the experiment we have to be aware that the quality of the metadata-based positioning depends on the quality of the provided metadata. Since we will use in parts the same learner profiles as in the first experiment we can compare the results of both experiments to control the added-value of integrating metadata in a positioning service. The approach for the research and development of a

positioning service is planned incrementally so we will also test the combination of a content-based and a metadata-based approach.
The third case will concentrate on the comparison of competence ontologies. In the third experiment we can compare the added-value of positioning of all three experiments and we can also model a combination. Assuming we will have a rich set of data (content, metadata and competence ontologies) how can a positioning service give a valid recommendation? Since the research project is divided into three phases defined by the above described cases, the result of every phase should add a model and techniques to the development of a prototypical positioning service.

Objectives and Expected Results

The first objective is the research and development of a model for a positioning service. The model should cover three cases for the comparison of similar competence related data and result in a recommendation for a starting position or an exemption decision inside a learning network. The second primary objective is the development of a prototype of a positioning service. This web service should support lifelong learners and help them to be positioned in learning networks. The computational support of the accreditation of prior learning is previously not well researched in the field of educational technology. Additionally the combination of the three cases for a lifelong learning perspective is unique and can provide a solution to bridge the previously unconnected contexts of lifelong learning. As a secondary result the project should stimulate the discussion of a positioning service for portfolio assessment and formulate requirements for electronic portfolios. Since the project will be carried out in the EU funded integrated project TENCOMPETENCE all results of the project will be published under an open source or open content license.

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