A SMS with a KISS. Towards a Pedagogical Design of a Metadata System for Adaptive Learning Pathways.[1]

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While there are many ontologies and metadata standards available in the field of Technology Enhanced Learning that support adaptive learning pathways, hardly any of these ontologies and metadata standards are ready for use and applied in professional education. Thus we suggest a simple metadata system (SMS) that considers educational theories, is kept simple and stupid (KISS) to increase usability and delivers pedagogical benefits.

Keywords: Learning Pathways, Adaptive System Design, Metadata System

1 Introduction

Learning Pathways express the chronological structure of pedagogical intentions. We suggest to use macro level relations between topics, henceforth called Concept Containers (CC), and micro level relations between content items, henceforth called Knowledge Objects (KO) to support pedagogical

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actions in the chronological structure. The objective is to deliver different individualised learning pathways with an adaptive system without enforcing one particular sequence of learning objects. The pedagogical benefit is that (1) teachers can create different Learning Pathways with the same content and (2) individual learners can deviate from that learning pathways. The difference between (1) and (2) is considered as a space which is relevant for becoming a person (Swertz et. al. 2013).

It is necessary to support the deviation of learners from learning pathways created by teachers or cybernetic systems since human freedom is an indisputable aspect of pedagogical processes. In this respect, it does not matter how reasoning is conceptualized. Critical (Kant 1974), communication theories (Habermas 1982), poststructuralistic (Foucault 1973) or other theories all need to consider freedom in some respect at least. In other terms: Being able to be free is characteristic for people. Freedom is a basic axiom that needs to be considered in pedagogical theories and in the professional practice. The demand for freedom applies to every individual learner, not just an abstract average. Therefore, providing freedom for each individual learner is relevant for professional pedagogical actions.

This connects to a second pedagogical axiom: pedagogical processes take place in time. While this timeliness is pretty obvious, it is not taken for granted that the future needs to be considered as open. One of the consequences of considering the future as open is that future human behaviour is unpredictable. For instance, the behaviour of an individual learner in a learning environment is basically unpredictable. Another consequence is that pedagogical actions can't be understood as cause-and-effect chains, but need to be understood as communicative processes (Hönigswald 1927). These communicative processes take place in a society. Thus the context of a society in a certain era and a certain culture influence pedagogical processes.

To consider freedom, openness, communication and contexts is not taken for granted in the design of metadata systems and ontologies. This can't be

discussed in detail for all existing concepts in detail here. Thus the learning path specifications as suggested by Janssen et. al. (2008, 2010) and Wong and Looi (2009) and are discussed as examples.

2 Selected Literature

The learning path specification as suggested by Janssen et. al. (2008) takes the international (which means European) exchange of courses and the mobility of employees in terms of life long learning as a starting point. It focuses on learning outcomes and tries to support learners in selecting learning pathways (Janssen et. al. 2008). With this prerequisites a list of ten characteristics of a learning pathway is developed: modular composition, nested composition, learning outcomes, entry requirements, selection, sequencing, temporal coordination, completion, conditional composition and substitution. This characteristics are connected to the IMS-LD specification.

With the focus on mobility of employees in the context of life long learning, the approach is clearly connected with political interests (Rothe 2011). While supporting neoliberal capitalistic ideas might be considered as appropriate today, it is certainly not an undisputed axiom for professional pedagogical actions. Pedagogical perspectives, like the freedom of the learner and the openness of the future, are skipped. Thus, the approach suggested by Janssen et. al. aims to create benefits in the context of neoliberal markets. Pedagogical benefits are not shown. Additionally, Janssen et. al. only considers learning outcomes. The difference between curricula (input) and competencies (outcomes), the difference of competencies and performance etc. (Euler 2014) are not discussed. Thus the communication between teachers and learners is not considered.

Wong and Looi (2009) suggest to model learning pathways by a combination of prescriptive planning like in Intelligent Tutoring Systems and inductive planning by Ant Colony Optimization. While their focus is on the observation of learner behaviour and performance, prescriptive paths and the ob-

servation of actual learner behaviour are combined with stochastic methods in order to create recommendations. This is done on the basis of an algorithm that describes how ants find food. This algorithm (ACO) is used to calculate recommendations with the DYLPA system, that considers not only a prescriptive pathway, but also preferences set by the learner.

With the combination of prescriptive and inductive planning, the system actually relies on deviant behaviour. It does not force a certain pathway, but computes recommendations based on teachers and learners behaviour. Thus the freedom of teachers and learners is taken into account. Still, the expression of different prescriptive pathways in the same course is not supported. Thus the freedom of the teacher is restricted.

Additionally, the system can not compute recommendations based on the behaviour of one individual learner, since it always computes learning pathways based on averages. While it is clear that people are pack animals, they are certainly not ants. Language can be considered as the relevant difference here (Chomsky 1999). Thus not all learners are necessarily interested in getting the biggest beacon for the colony on the shortest way. Some might even be interested in fooling other learners in order to get the biggest beacon for themselves. This might be considered as a recommended behaviour in a competition driven capitalistic economy, but not in an ant colony. The cultural context in ant colonies and human societies is no the same. Additionally, Wong and Loi do not consider the difference between natural evolution and artificial micro evolution (Henning 2008). Consequently, taking the average learner behaviour to calculate recommendations for other learners with an algorithm that is based on the observation of ant behaviour is problematic.

Due to the problems mentioned above we suggest a different approach to create an adaptive recommendation with learning pathways. This approach aims to focus on the individuality and the freedom of teachers and learners by creating a system that supports unpredictable and deviate behaviour of teachers and learners.

3 Pedagogical Learning Pathway Recommendations

Our understanding of learning pathways is based on the definition by Meder. According to Meder (1998), learning pathways are the projection of knowledge into the time of learning. While knowledge is at least in some respect considered as timeless (Hönigswald 1927), it needs to be transformed into a temporal communication process pedagogical purposes. In order to support the transformation into computer based communication, Meder describes a difference between Concept Containers and Knowledge Objects. Concept Containers (CC) are defined by a topic and their relations represent the structure of a domain. Knowledge Objects (KO) are located in a CC and contain different media, tasks, scripts etc. about the same topic. Relations between KOs represent the pedagogical intention. This allows to express learning pathways on the level of CCs and on the level of KOs by setting relations between CCs and KOs.

Meder complements this structure with a comprehensive metadata vocabulary. This vocabulary is based on established teaching and learning strategies and thus restricts teachers to those strategies. But Meder created his vocabulary as an example only. It is meant to be extended by pedagogical experts as needed. Thus only the basic structure (CCs, KOs, typed relations) is actually fixed. The vocabulary has to be considered as dynamic. Since we intended to focus on the freedom of the teachers, we modelled the concept containers and the knowledge objects only, which have to be connected by relations that form directed acyclic graphs. The relations have to be labelled (with the existing or extended vocabulary) and described. The label and the description are presented to the learner later on. The metadata vocabulary requires teachers to add four variables to set up the sequences. This can be considered as simple.

This metadata allow the expression of any pedagogical concepts (constructivistic, behaviouristic, cognitivistic, evidence based etc.) which are understood by learners later on. To support this communication process it is only

necessary that a teacher expresses his ideas by creating learning pathways and describing the intention of that pathways.

For the implementation of our concept, a pedagogical ontology was created in OWL. To connect this ontology with content, interfaces to five common LMSs (like Moodle and Ilias) were implemented. This extends the pedagogical capabilities of the LMSs, since none of them supported different learning pathways in the same material before. Additionally, it is possible to create learning pathways across LMSs.

While Meder considered adaptivity in terms of different learning pathways, he did not describe strategies that allow for the calculation of recommendations, especially in the case of deviate learner behaviour during learning processes. Extending his approach, we thus had to specify criteria to calculate recommendations and a system to create them. This system (INTUITEL) acts as an extension to common Learning Management Systems (LMSs) like Moodle and ILIAS. To connect those eLearning systems with the ontological description of Learning Objects (CCs and KOs), a general interface was specified, which allows to exchange course and learning data. This extends the capabilities of the LMSs, since none of them supported different learning pathways in the same material before.

There are three data sources that can be used to create recommendations:

1) Learning Pathways as created by the teachers.
2) Informations from the learner model.
3) The recorded behaviour of learners.

While the learning pathways are stored in OWL based cognitive maps (CM) outside of the LMSs, the learner model and the recorded behaviour of learners are obtained from the LMS and stored internally. For recommendations, didactical factors (DF) are calculated from this information in a learner progress model (LPM) every time the learner accesses the knowledge domain. The didactical factors range from simple data like the last login to more complex data like the preferred micro learning pathway of an

individual learner in the last five concept containers visited. By combining all this data, the system can determine the most appropriate element(s) on the learning pathways for any particular learner.

Furthermore, the systems supports actions like (1) changing the learning pathway at any point during the learning process, (2) using individual a learning pathways that are calculated based on the recorded behaviour of the individual learner or (3) use a learning pathway that has been created by other learners. The decision is taken by the individual learner. We consider this as a pedagogical game between teachers and learners (Swertz et. al. 2013).

To bring the idea into practice, we created an online course for a basic lecture in a bachelor program. The course is visited by about 800 students per year. The domain (General Didactics) is covered by 103 topics. Accordingly, 103 CCs were created. These concept containers were connected by four different learning pathways (bottom up, top down, chronological forwards, chronological backwards). Each concept container is filled with 10 KOs. These knowledge objects were connected with three different learning pathways (programmed instruction, multi stage learning, inquiry based learning).

Thus it could be shown that it is possible to use different pedagogies within one CC and inductive or deductive learning pathways between the same CCs. Recommendations were successfully calculated. This, however, yet only demonstrates a small part of which is possible with the suggested approach. Since there are only minimal constraints present, combining various pedagogical approaches in one course becomes possible.

4 Conclusion

The adaptive learning pathway recommender system design suggested here is based an two pedagogical axioms: the individuality and the freedom of teachers and learners. It overcomes the limitations of existing systems and

supports teachers in creating arbitrary and multiple learning pathways within a knowledge domain. Reusing content is supported. Learners can follow the learning pathway as created by the teacher, change the pathways during the learning process or create their own learning pathways. To support this, a simple metadata system with two types of relations is used. The ontology is expressed in OWL.

The system design minimizes the determination of teacher actions. By supporting different learning pathways, cross LMS pathways and allowing for ontology extensions the pedagogical options are increased. The decisions taken by the teachers do not determine the actions of learners and thus consider the freedom and the openness of the learner's future. This can be considered as a pedagogical benefit.

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