Evolution of Interests in the Learning Context Data Model

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Abstract. A key area of application for Learning Analytics (LA) and Educational Data Mining (EDM) is lifelong learner modeling. The aim is that data gathered from different learning environments would be fed into a personal lifelong learner model that can be used to foster personalized learning experiences. As learning is increasingly happening in open and networked environments beyond the classroom and access to knowledge in these environments is mostly context-sensitive and interest-driven, learner's contexts and interests need to constitute important features to be modeled. The context data of a learner as it is already represented by the Learning Context Data Model (LCDM) specification, describes the learner's activities, her biological conditions, as well as the characteristics of the learning environment. Towards a lifelong learner model, a model consisting of context data can further be refined with an evolving set of interests. This paper describes an approach to extend the existing LCDM specification with interests, taking into account the importance of the interests as well as their evolution over time.

Keywords: Interests, Mobile Learning, Data Model, Lifelong Learner Model, Open Learner Model

1 Introduction

Learning modeling is a crucial task in the emerging research areas of learning analytics (LA) and educational data mining (EDM) [5]. A learner model represents information about a learner's characteristics or states, such as knowledge, motivation, meta-cognition, and attitudes [1]. A learner model is also a representation of information about an individual learner that is essential for adaptation and personalization tasks [1]. A big challenge to tackle here is lifelong learner modeling. Kay and Kummerfeld [7] define a lifelong learner model as a store for the collection of learning data about an individual learner. They note that to be useful, a lifelong learner model should be able to hold many forms of learning data from diverse sources.

The six most popular and useful features in (lifelong) learner modeling include the learner's knowledge, interests, goals, background, individual traits, and context [2]. Context is a central topic of research in the area of learner modeling. The capacity to build a detailed picture of the learner across a broader learning context would provide

adfa, p. 1, 2011.

more effective personalized learning experiences. A context model should reflect a complete picture of the learner's context information [4].

In the frame of the Learning Context Project[1], we proposed the Learning Context Data Model (LCDM) specification as a possible standard representation of context data, thus enabling the interoperability and reusability of context models [10].

In addition to context, learner interests build another important aspect in learning modeling. As access to information in today's open and networked learning environments is mostly interest-driven, learner interests need to constitute an important learner feature to be modeled in order to help learners overcome the information overload problem. The capacity to mine learner's interests across different learning contexts would provide more effective personalized learning experiences for lifelong learners.

Recognizing the importance of the interest dimension in the learner modeling task, we implemented an extension of LCDM which is able to hold weighted interests of the learners towards a lifelong learner model.

2 Interest Modeling and Development

According to Krapp [8], an interest represents "a more or less enduring specific relationship between a person and an object in his or her life-space". An object of interest can be any type of content like a certain topic, an abstract idea, or a concrete object which is somehow connected with the person's life-space. A learner may have multiple interests at the same time but at each point in time, she can only have a deeper interest in some of those objects, topics or activities. Such a closer relationship may last over a longer period of time and can be seen as a consolidated interest of the person. The personal importance of interests may also change over time; some will be more important while other interests loose importance or disappear completely [8].

The three stage model described by Krapp explains the evolution from the first occurrence of a certain interest to a longer-lasting individual interest. In general, interests are divided into two main types: situational and individual interests. A Situational interest is mostly triggered externally in a given learning environment. Such interests can develop to individual interests when the person spends a lot of time on them and identifies herself with them. The already mentioned three stage model additionally divides the situational interest into two different stages while the individual interest is described by the last of the three stages. The first stage defines the first occurrence of an individual interest while the second stage describes a stabilized situational interest that lasts through a particular learning phase. In general, a learner has more interests on stage one than individual interests on stage three.

3 Implementation

The implementation of the extension of LCDM with interests was done in four steps. The first step was to define the new version of the model itself by considering

[1] http://www.learning-context.de

different quality requirements. Step two defined the weighting of the different interests, how they affect each other and when the transition between the different stages happens. For adding new interests to the model and for requesting the resulting data, the already existing RESTful API has been extended in step three. For exhibiting the different stages of an interest enriched model, the step four described how a prototypic visualization can look like. These four steps are addressed in the following sections.

3.1 Interest Data Model

The underlying data model of the Learning Context Project has a high impact on the complete system because the flexibility and the complexity depend on the quality of the data model [9]. Besides the semantic requirements of the data model, general requirements for an entity relation model need to be fulfilled to develop a high quality data model. Moody [9] describes eight general requirements of a data model (completeness, integrity, flexibility, understandability, correctness, simplicity, integration and implementability) which are the foundation of any modification of this model.

All interests are specified by the relationship between a person and a certain object which can be represented by a topic, an idea, or by a term. Interests are not static and may develop or ascend to / descent from the described three stages. The model also needs to contain information about the point in time when the learner is interacting with an interest related object. This information is necessary to be able to specify the importance of an interest and also to specify to which stage the interest belongs to. If the user was interested in an object over a certain time period and engaged frequently enough with this interest, it can ascent to the next stage. The model should also distinguish between different types of interests. Persons can e.g. have private, academic and work related interests. Every interest is influenced by all other interests and vice versa. If a learner suddenly gets interested in a new topic A, the importance of all the other interests will drop, while interest A is rising in importance. So the modeled interests need to have a weight, which can be adapted, based on the importance of the events that are related to those interests.

The following list gives a summarizing overview over all interest related requirements:

- Interests are represented as relationships between a person and an object
- Multi-stage model of interests
- Different interest types: private, work, academic
- Every interest has a weight to describe its importance and development
- Ranking of interests

Driven by these requirements, the interest-enriched version of LCDM (see **Fig. 1)** has been implemented in several iterations. Interests are linked to events because they are the central objects. Events could be actions like opening a learning resource or like writing a scientific paper. They may have zero to n related interests, for example if someone writes a paper, it normally covers more than one interest.

3.2 Weighting

The general idea behind the calculation of the weight for each interest is that a learner only has limited time and attention which can be seen as a resource, a learner can assign to her different interests. The weight of a new interest is calculated by multiplying a user-defined value for initial weightings of new interests with an – also user-defined – factor for the application which wants to add the new interest. We introduced such an app-based factor to let the learner decide which applications generates more important interests or which generate less important ones.

All the events which have effects on the weighting of interests are collected for one day to be normalized. After this re-calculation of the weights of all the interests, a new history entry is added to the database. The advantage of this procedure is that the runtime of the atomic event of adding, deleting and merging can be decreased a lot if the new weights are not calculated in real time.

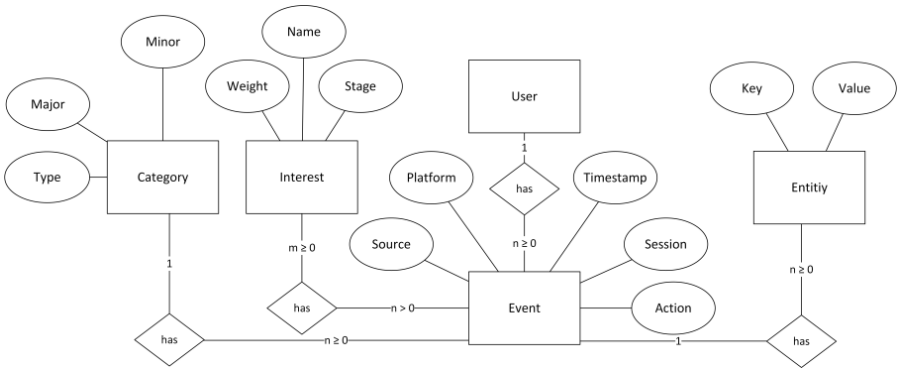

Fig. 1. The current version 4 of LCDM

Since interests may lose their importance if they are not refreshed regularly, a *Forgetting Function* has been introduced. It decreases the weight of an interest based on the time interval between the last date the learner interacted with this interest and the current date. Cheng et al. [6] introduced a function to describe the attenuation of human interests. It was also used as a basis to model the decreasing weight of non-refreshed interests by changing the used half-life *hl* to control the speed of forgetting.

$$F(d) = e^{-\frac{\ln(2)*d}{hl}}$$

The parameter *d* represents the difference between the date of the last occurrence of the interest and the date, where the new interest weight is calculated. Difference *d* and half-life *hl* are both expressed in days.

3.3 LCDM API

We implemented an extension of the existing LCDM API to make the data model accessible by third-party applications. The interest-related subset of the API provides

full access to the interest model with a complete set of CRUD (create, read, update, delete) functions that enable requesting, adding, updating and deleting interests including their complete history. As an example, sending a GET request to the interface *interests* will return all interests of the current learner with *name*, *weight*, *stage*, *type*, and the *timestamp* of the last update sorted by weight. By using the parameter *top*, only the top n interests are returned. For deleting interests, the names of all interests that should be deleted have to be sent to the server via a DELETE request. The corresponding interest with the complete history and the connection to the events are deleted.

Another important functionality of the API is merging two interests when two interest names are stored in the system which have the same meaning but which are probably spelled differently. The first interest is used as the base for the new merged interest. All events and history entries related to the second interest are related to the base interest after merging. To combine the two weights, each of them is decreased with the Forgetting Function. After calculating the sum, the second interest is deleted and the first one is updated.

3.4 Visualization

For an open learner model [3], the learner should be able to inspect and manage the data which is stored about her. The first module (see **Fig. 2**) which visualizes the development of different interests over time makes the available interest data easier to grasp for the learner. Moreover, it enables self-reflection about the own interests and to set or alter the personal priorities.

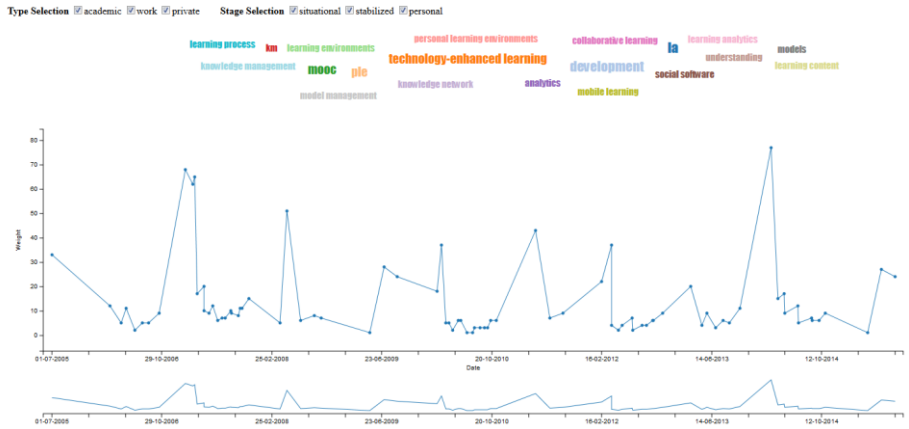

Fig. 2. Visualization for the evolution of different interests

The second module is for managing the existing learners' interest. It contains an overview of all interests with the related information about the weight, stage and type of the interest. This module further supports open learner modeling by enabling the learner to edit, merge and delete her interests.

4 Conclusion

Lifelong learner modeling is crucial to achieve personalized learning experiences. Context and interests represent important features in the lifelong learner model. Towards a lifelong learner model, we proposed in this paper an extension of the existing Learning Context Data Model (LCDM) specification with interests, taking into account the weights of the interests as well as their evolution over time. We followed an iterative approach to develop a new version of LCDM which satisfies specific interest-related requirements from a psychological perspective. We further provided an API which enables requesting, adding, deleting, updating, merging, and visualizing interests.

The current version of LCDM which encompasses context and interest information about a learner can further be extended with other attributes of a learner model such as knowledge, goals, background, and individual traits in order to build a complete lifelong learner model.

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