LEA's BOX: Practical Competence-oriented Learning Analytics and Open Learner Modeling

Michael D. Kickmeier-Rust
Graz University of Technology
Knowledge Technologies Institute
8010 Graz, Austria
+43 316 873 30636
michael.kickmeier-rust@tugraz.at

Susan Bull
University College London

Dietrich Albert
Graz University of Technology
Knowledge Technologies Institute
8010 Graz, Austria
+43 316 873 30640
dietrich.albert@tugraz.at

ABSTRACT

Big Data and data technologies increasingly find their way into school education. Learning Analytics and Educational Data Mining are focal research areas. However, technical solutions often fail to meet the practical requirements of teachers or to really mirror human learning processes. The LEA's BOX project aims at developing a practical web platform that hosts tools for a theory-based approach to Learning Analytics and that offers tools to open and negotiate learner models.

Keywords

Learning analytics, data visualization, open learner models.

1. INTRODUCTION

Using Learning analytics and educational data mining are more than recent buzz words in educational research: they signify one of the most promising developments in improving teaching and learning. While many attempts to enhance learning with mere technology failed in the past, making sense of a large amount of data collected over a long period of time and conveying it to teachers in a suitable form is indeed the area where computers and technology can add value for future classrooms. However, reasoning about data, and in particular learning-related data, is not trivial and requires a robust foundation of well-elaborated psycho-pedagogical theories.

The fundamental idea of learning analytics is not new. In essence, the aim is using as much information about learners as possible to understand the meaning of the data in terms of the learners' strengths, abilities, knowledge, weakness, learning progress, attitudes, and social networks with the final goal of providing the best and most appropriate personalized support. Thus, the concept of learning analytics is quite similar to the idea of formative assessment. "Good" teachers of all time have strived to achieve exactly this goal. However, collecting, storing, interpreting, and aggregating information about learners that originates from a school year, or even in a lifelong learning sense) requires smart technology. To analyse this vast amount of data, give it educational meaning, visualize the results, represent the learner in a holistic and fair manner, and provide appropriate feedback, teachers need to be equipped with the appropriate technology. With that regard, a substantial body of research work and tools already exist. This project aims to continue and enrich on-going developments and facilitate the broad use of learning analytics in the "real educational world.

2. LEA's BOX

LEA's BOX (www.leas-box.eu) is a project, funded under the EU's Seventh Framework Programme and stands for a practical LEarning Analytics tool Box, that provides

- a competence-centred, multi-source formative assessment methodology,
- based on sound psycho-pedagogical models (i.e., Competence-based Knowledge Space Theory and Formal Concept Analysis),
- intelligent model-based reasoning services,
- innovative visualization techniques,
- and features to open and negotiate learner models;

LEA's BOX is dedicated to develop a learning analytics toolbox that is intended to enable educators to perform competence-centered, multi-source learning analytics, considering their real practical needs. Thus, the project spends significant efforts on a close and intensive interaction with educators in form of design focus groups and piloting studies.

The tangible result of LEA's BOX manifest in form of a Web platform (Figure 1) for teachers and learners provide links to the existing components and interfaces to a broad range of educational data sources. Teachers will be able to link the various tools and methods that they are already using in their daily practice and that provide software APIs (e.g., Moodle courses, electronic tests, Google Docs, etc.) in one central location. More importantly, the platform hosts the newly developed LA/EDM services, empowering educators to conduct competence-based analysis of rich data sets. A key focus of the platform will enable teachers not only to combine existing bits of data but to allow

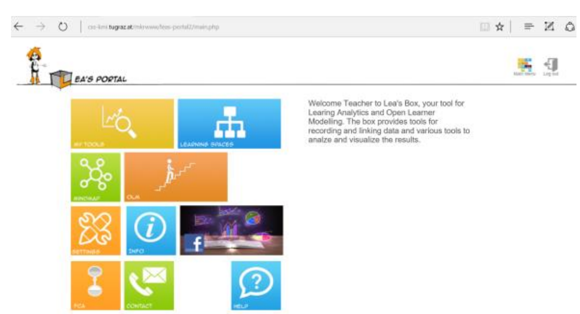

Figure 1. Central web platform

them to “generate” and collect data in very simple forms, not requiring sophisticated hard- or software solutions. Finally, we want to open new ways to display the results of learning analytics - leaving the rather statistical dashboard approach, moving towards structural visualizations and towards opening the internal learner models.

3. Open Learner Models

Learner models contain and dynamically update information regarding users’ learning: current knowledge, competencies, misconceptions, goals, affective states, etc. There is an increasing trend towards opening the learner model to the user (learner, teacher or other stakeholders) to support reflection, encourage greater learner responsibility for their learning, and help teachers to better understand their students (Bull & Kay, 2010). The core requirement is that such visualizations must be understandable to the user. Although this may appear to be similar to the more recent work on LA, open learner models (OLM) concentrate more on the current state of learners, with less references to activities undertaken, scores obtained, materials used, contributions made, etc. OLMs typically focus on concepts, competencies, and guiding learners with regard to conceptual issues rather than specific activities and performance. Various OLM visualization examples have been described in the literature for university students (see Bull & Kay 2010, for a more detailed overview). The most common visualizations used in courses include skill meters, concept maps and hierarchical tree structures.

In addition to visualizing the learner model, various methods of interacting with the learner model exist, ranging from simple inspectable models, which allow some kind of additional evidence to be input directly by users, to negotiated learner models, in which the content of the learner model is discussed and potentially updated. We focus on the latter. Key features of negotiated learner models are not only that the presentation of the learner model must be understandable by the user, but also that the aim of the interactive learner modelling should be an agreed model. Most negotiated learner models are negotiated between the student and the teaching system. However, other stakeholders can also be involved, and the notion of “the system” can be broadened to include a range of technologies, such as the ones used in technology-enhanced learning. Here we consider (i) fully-negotiated learner models; (ii) partially-negotiated learner models; and (iii) other types of learner model discussion. They are all relevant to our notion of negotiating the learner model or its content, and they are adapted for LEA’s BOX (Figure 2). theoretical approach to do so is Competence-based Knowledge Space Theory (CbKST, Albert & Lukas, 1999). The approach is a mathematical psychological, set-theoretic framework for addressing the relations among problems (e.g., test items). It

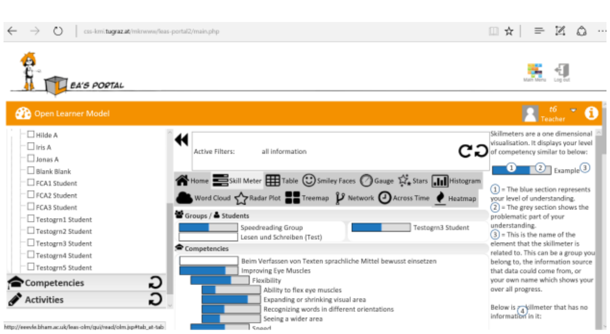

Figure 2. OLM in LEA’s BOX

provides a basis for structuring a domain of knowledge and for representing the knowledge based on prerequisite relations. We interpret the performance of a learner (e.g., mastering an addition task) in terms of holding or not holding the respective competency. In addition, recent developments of the approach are based on a probabilistic view of having or lacking certain competencies. In our example, mastering one specific addition task allows the conclusion that the person is able to add two numbers (to hold this competency) only to a certain degree or probability. When thinking of a multiple-choice item with two alternatives, as another example, mastering this item allows only to 50 percent that the person has the required competencies/ knowledge. On the basis of these fundamental views, CbKST is looking for the involved entities of aptitude (the competencies) and a natural structure, a natural course of learning in a given domain. For example, it is reasonable to start with the basics (e.g., the competency to add numbers) and increasingly advance in the learning domain (to subtraction, multiplication, division, etc.). As indicated above, this natural course is not necessary linear, which bears significant advantages over other learning and test theories.

As a result we have a set of competencies in a domain and potential relationships between them. In terms of learning, the relationships define the course of learning and thus which competencies are learned before others. Because of the mathematical nature, we can develop LA algorithms on this basis. The results, in turn, provide not only summative analyses but also formative and predicative information, as well as model-based recommendations (Kickmeier-Rust & Albert, 2015).

5. OUTLOOK

The project is now in in its second year and a stable, open, and configurable web platform with a set of internal tools as well as a negotiable OLM instance is available. Presently we are running use case studies on a large scale in Austria, Germany, the Czech Republic and Turkey. The results so far a highly promising and reveal the potential added value of theory-driven LA and open presentation of results to educators and teachers.

6. Acknowledgements

This work is supported by the European Commission (EC) under the 7th Framework Programme for research and development as well as the running LEA’s BOX project, contracted under number 619762. This document does not represent the opinion of the EC and the EC is not responsible for any use that might be made of its content.

7. References

Bull, S. & Kay, J. (2010). Open Learner Models, In R. Nkambou, J. Bordeau and R. Miziguchi (Eds.), *Advances in Intelligent Tutoring Systems* (pp. 318-338), Berlin-Heidelberg: Springer-Verlag.

Albert D. & Lukas J. (1999). *Knowledge spaces: Theories, empirical research, applications.* Mahwah: Lawrence Erlbaum Associates.

Kickmeier-Rust, M. D., & Albert, D. (2015). Competence-based Knowledge Space Theory: Options for the 21st Century Classrooms. In P. Reimann, S. Bull, M.D. Kickmeier-Rust, R. Vatrapu, and B. Wasson (Eds.), Measuring and Visualizing Learning in the Information-Rich Classroom (pp. 109-120). New York, NY: Routledge.