Towards Software-Supported Large Scale Assessment of Knowledge Development

Andreas Mühling  
TUM School of Education  
Technische Universität München  
Boltzmannstr. 3  
85748 Garching, Germany  
muehling@in.tum.de

Peter Hubwieser  
TUM School of Education  
Technische Universität München  
Boltzmannstr. 3  
85748 Garching, Germany  
peter.hubwieser@tum.de

ABSTRACT
Measuring the effects of teaching on a larger scale is a promising approach in educational research. However, the costs for manual or semi-manual methods are prohibitively large when dealing with larger groups of students. Automated system are needed therefore, to assist in the process of collecting and evaluating the data. To this end, we propose a system of 3 components that allow the large scale assessment of concept-maps in order to detect the development of knowledge and misconceptions of larger groups of students.

Categories and Subject Descriptors
K.3.0 [Computers and Education]: General; I.5.4 [Pattern Recognition]: Applications—Text processing

Keywords
concept maps, educational data-mining, AIED, large-scale assessment, online survey, automated assessment

1. INTRODUCTION + RELATED WORK

The assessment of structural knowledge with the help of concept maps has a long tradition in science education (e.g. [3], [6], [10] and [5]). Also, there are a number of software tools that allow the electronic editing of concept maps. However, many of them are based on the learner’s perspective and are not suitable for the assessment of the maps or require the local installation of software (like [2]).

When assessing the effects of teaching on a larger scale, researchers are often faced with the problem of handling large amounts of data. Software-based solutions can help to remedy this problem. For the collection of data there are several online surveying tools that represent a feasible solution. Nevertheless, the assessment of the data remains expensive in many cases. Consequently, we should aim at automating this task as far as possible. Obviously, there are assessment tasks that - at the moment - cannot be automated to an extent that matches the outcomes of the assessment by a human being. However, in these cases we might still benefit from a semi-automated or even fully-automated solution as the amount of manual labour that would be required otherwise might be prohibitively large. In other words: Even if the results are not optimal, they might still be better with automation than without it. Considering this, we propose a system that will automate the sub-tasks of the assessment of knowledge-structures and misconceptions that are represented by concept maps.

A list of the relevant concepts is often needed for the collection or for the assessment of concept maps, e.g. to be presented to the test persons as a starting point for their drawings or to assess the completeness of the collected maps. To generate such list of concepts out of the course material, we are relying on natural language processing. While there are many concurrent ideas and solutions to NLP-problems, they usually require a very task-specific fine-tuning of the method. Extraction of technical terms or terms of interest from a corpus of text is a common problem that encompasses among others, the ideas of Latent Semantic Analysis [8] and part-of-speech tagging. Besides extracting a list of concepts, there has also been research on extracting the relation between concepts automatically [1] and using ontology-based knowledge during the creation of concept maps [9]. Based on these ideas, we aim to design three software tools as components of an integrated solution: ConEx (Concept Extraction), CoMapEd (Concept Map Editor) and CoMaTo (Concept Mapping Tools).

2. CONEX - AUTOMATED EXTRACTION OF KNOWLEDGE ELEMENTS

The goal of the ConEx component is to extract knowledge elements from a given text automatically. Ideally, a researcher or educator would use the material that has been presented to students as the input and receive a list of concepts and relevant propositions from the course material. This can then be used as a reference for what the students “could know”. Since many concept map scoring systems rely on expert knowledge (e.g. in form of a “master map” [3]), such a list could be used instead of having an expert draw a map. We employ a part-of-speech tagger that is part of the Stanford NLP software distribution [4] and Princeton University’s WordNet® 

is used to extract nouns from the text as those are candidates for concepts. To disambiguate multiple word-forms that might occur, we use WordNet to get a base form for each noun - if possible. The list of candidates obviously includes many nouns that don’t make valid concepts for the subject-domain (e.g. ‘exercise’ or ‘chapter’ when using textbooks as a basis). Using only the k most frequently occurring candidates as concepts yields usable result. However, there are typical wrong terms, like “figure” or “table” that are overrepresented in a textbook and are thus treated like a technical term by the system. To counter this, we are currently trying to build a baseline corpus of texts, that are similar in form but from different subject areas (e.g. textbooks from physics and history). Using this base-line corpus we can employ the well-known \( TF*IDF \) (term frequency inverse document frequency) weighing scheme. This scheme offsets the relative frequency of a term in one document with the number of documents in the baseline corpus that contain this term. In other words: If a term appears very often in the baseline, it will get a low weight, even if it appears very often in the document we are analyzing.

Starting with this list of concepts, we are then extracting every sentence that contains a combination of the concepts. Each such sentence is assumed to contain relevant knowledge that can be represented in a concept map, somehow. Clearly, there is a lot of noise in the data, but manually analyzing the book would take up too much time and thus is not an option.

3. COMAPED - ONLINE SURVEYING OF CONCEPT MAPS

Based on the requirements of a large scale online assessment tool, we developed CoMapEd. It is browser based, so in today’s world it should be usable on almost every computer that has internet access. The platform is HTML 5 and JavaScript which are both supported by every major browser. The tool allows to create open or closed surveys (where participants will get an invitation with a code). Users can come back to their maps any time and change or export them. On the back-end, the researcher or educator can also export the maps of a survey. Also, the edges of the concept map can be scored and it is possible to mine the data very efficiently by creating filters that operate on all the edges of all the maps at once. It is possible to restrict the maps to a given list of concept and also to a given list of possible edge labels, if desired. This approach makes automatic scoring much more feasible, since the number of possible propositions is restricted and there are no problems with semantically identical buy syntactically differing propositions.

4. COMATO - CONCEPT MAP ANALYSIS

Finally, in order to investigate the concept maps in detail, we are currently developing a package for GNU-R [7] called CoMaTo that is able to import concept maps form a variety of sources (e.g. the TGF and GraphML format for graphs, as well as table based representations of concept maps that one might encounter in CSV files or spreadsheets). It offers methods to analyze the concept maps based on measures found in literature (e.g. [3]) as well as our current research on structures in knowledge [10]. Our main goal is to identify structural properties of concept maps.

5. RESULTS AND FUTURE WORK

Currently, we are testing CoMapEd in a longitudinal study of a CS1-course. About 50 participants are constantly expanding a concept map about the course topics. They are non-majors and were able to work with the tool without any guidance (they did however receive guidance about concept mapping). ConEx and CoMaTo are currently in development. Especially the automatic extraction of knowledge elements is a highly non-trivial task that will require further research into what methods may turn out to work well in this scenario. When applying ConEx to a textbook on Java Programming, the 5 most salient concepts returned are: \textit{method, class, line, java, object}. Clearly, we will never be able to get a full, semantically correct extraction by software - but we hope to get a working system that is able to extract a list that’s good enough so that only minimal human intervention is needed. A further are of research deals with trying to automatically score the concept maps with the use of the extracted knowledge elements.

6. REFERENCES


[10] Peter Hubwieser and Andreas Muhling What Students (should) know about Object Oriented Programming In ACM:Proceedings of the 7th International Computing Workshop 2011, Rhode Island, USA.