E-portfolios for Meaningful Learning and Automated Positioning

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Abstract. When it comes to lifelong learning and e-learning, we are steadily moving towards distributed and self-organized networks where multiple content providers offer parts and pieces, not complete vertical systems. This spurs development of new methods and techniques to position learners in these networks. Positioning requires that characteristics of the learner are mapped onto characteristics of learning materials and curricula. In this paper we describe BrainBank Learning, a web application for construction of individual topic maps as a mean for learning, and discuss the potential of such knowledge maps for automated computer-supported positioning. We also present current work on developing, evaluating and utilizing topic maps-based applications to support meaningful learning and deeper understanding.

Introduction

Web-based learning has in general become more popular in education and business training. A lot of computer-aided learning software exist to aid learning, web applications as well as offline systems. The tools vary from customized learning applications to edutainment and simple communication systems. However, abundant digital resources and tools do not necessarily solve any problems if they by the end of the day contribute to increase the chaotic pressure of information on the learners. The main problems related to using educational hypertext for learners are cognitive overload, disorientation and distraction, poor narrative flow, and poor conceptual flow [1].

Educational practices are changing from being predominantly teacher-led to largely student-centered. But how can the students themselves be able to assess their position relative to a future learning environments consisting of a diverse set of learning activities from which learners somehow may take their pick? The learner’s history and goals define an entry position relative to the learning activities. A different entry position is likely to result in a different partition of the set of available activities in activities to skip and to complete. Different entry points will thus result in different paths through the set of relevant learning activities. Computer supported positioning in learning networks could contribute to the formidable set of hurdles that arises in such a scenario. In fact, it assumes answers on a substantial number of the research questions that were recently proposed for intelligent information systems [2]. In this article we focus on how the learner’s history can be recorded and stored in electronic portfolios.

Electronic portfolios have traditionally been defined as an organized collection of digital and/or analog artifacts and reflective statements that demonstrate growth over time [3]. In a broader perspective e-portfolio has been defined as a tool that can provide sophisticated control of one’s virtual identity [4]. A fundamental characteristics of an e-portfolio in this perspective is that the *virtual identity* is stored using a common set of functional and organizational standards. Wilbert Kraan puts it this way: “Without the means to output e-portfolio data in a standard format, it's next to useless” [5].

Topic Maps [6] is a hypertext navigation meta-layer above electronic information sources supporting topical finding of various kinds of resources, e.g., documents, graphics, images, database records, audio/video clips. As a result of a special characteristic of the topic maps model is a clear separation between the description of the information structure and the physical information resources. The navigation meta-layer is independent of the format of the actual resources and enables the creation of an external index that makes the information findable. The main topic maps components are topics, associations, and occurrences [7]. Using those elements, one can create maps in document repositories.

The topics represent the subjects, that is, the things that are in the application domain, and make them machine process-able. They can have zero or more topic types and also have names (a base name and variants for use in specific processing contexts). A topic association represents a relationship between topics. Associations can have types (e.g., illustrated by, example of, written in, etc.) and define roles of the participating topics (e.g., example—concept description; prerequisite— result; document—language). Occurrences instantiate topics to one or more relevant information resources. An occurrence can be anything; most often it is a URI or a document (article, picture, video, etc.).

Scope defines the extent of validity of a topic characteristic assignment: the context in which a name or an occurrence is assigned to a given topic, and the context in which topics are related through associations. One useful and potentially very powerful application of scope is to permit capture of different viewpoints of the subject. Another important concept in TM is identity. Two topics are the same if both have the same name in the same scope or both refer to the same subject indicator. The topics and all their characteristics could be merged if this condition holds. Topic maps provide a language to represent the conceptual knowledge with which a student can distinguish learning resources semantically. Apart from their major purpose of indexing information resources, topic maps embody knowledge. A semantically rich topic map would enhance the value of a teaching unit. Moreover, topic maps are very suitable for representing the course unit ontological structure.

In a recent paper Dichev et al [8] discuss the advantages of Topic Maps in education from 3 perspectives; the learners`, authors` and courseware developers` perspectives. Authors will benefit from knowledge externalization support, effective management and maintenance of knowledge and information, augmented learning space beyond teaching space, rapid and efficient courseware development, collaborative authoring and personalized courseware presentations. For courseware developers Topic Maps supports building ontology-aware applications, open ended learning environment, adaptive educational applications and courseware templates. It offers enhanced navigational retrieval tools, reuse, sharing and interoperability, and TM tools and API's are available from several, including open, sources. Moreover, for the learners Topic Maps offers efficient context- based retrieval of relevant online information, acquisition of new topical knowledge, deeper understanding of the domain conceptual relations, better information comprehension true visualization, domain navigation and browsing awareness, and finally customized views, adaptive guidance and context based feedback

For some reason, Topic Maps has so far not been utilized extensively for education and learning purposes. In fact, we are only aware of a few such commonly available applications. Dicheva et al [9] has recently developed TM4L (Topic Maps for Learning), a framework supporting the development of ontology-aware repositories of learning materials. Our contribution, BrainBank Learning, has been focused on learning, rather than education. The main goal of the work presented in this paper was to build a bottom-up application where the learners can construct their own learning ontology and curriculum during a course or a complete study.

Results and Discussion

BrainBank Learning

BrainBank Learning (BBL) [10] was developed as a web application (http://brainbank.no) for learning of concepts (their content) and associations (how concepts relate). It works with standard Internet browsers, which means that educational institutions are not dependent on any other installation to use the application. Users enter the application through individual accounts. Topics (concepts) that the learner meets during education activities are entered and described. The topics can then be connected by linking phrases to form propositions or associations: The learner creates his own associated network of topics that represents his knowledge. This way of documenting in the learning process is good for the learner's understanding of the area of study (placing knowledge in a context), as well as navigating and overview of the acquired knowledge later on. To further describe topics and associations, digital resources such as documents, pictures, movie clips and sound clips can be attached to the topics. These resources can be either linked to or uploaded to and stored in BrainBank. BBL is based on the Topic Maps standard, including the XML format supporting the Topic Maps ISO standard (XTM) [11] and it was implemented using the Ontopia Knowledge Suite [12]. As the Topic Map standard defines an effective way of representing information (through topics and associations etc.) [13], BBL now uses this Topic Maps technology to represent the data in the application.

A case study has been done to evaluate practical use of BBL and to find out if it helps improve learning to become more effective. The project has been a cooperative effort between Krsitin Bjørndal at PLP (Program for learning and practical pedagogy at the University of Tromsø), Cerpus AS and Alsvåg primary and secondary school. The project has been reported [14] and thoroughly discussed [15] elsewhere and the main focus here is rather to catch on with unleashed potential and prospects for improvement. Based on the replies from the pupils (in interviews), three separate aspects were identifiable: BBL as an e-porfolio, as a learning strategy and as a medium and method for assessment.

E-portfolio

The pupils expressed that they would prefer to structure and store their knowledge in BrainBank rather than in paper notebooks. Pupils often think of repetition of learnt material as boring, but it is widely acknowledged that repetition is one of the best ways of *storing* knowledge. Seven out of the group of sixteen pupils stated that BBL helped in remembering what they had learned. According to these pupils, BBL mainly helped because they could easily go back and take a look at what they did earlier, what they had written down of keywords and associations (e.g.: *"We can save things, so we won't forget it. It's simply to enter BrainBank, and there we have it. It's easy to save and easy to retrieve. We learn more and more through the years."*) The same pupils said that they regularly used BrainBank to repeat for themselves what they had learned (e.g.: *"You kind of get a repetition of what is learned when typing it into BrainBank. When I'm in 9th grade, I can look back on what I learned in 8th grade.").* The pupils also expressed that they were motivated to document their knowledge thoroughly by the fact that it is properly stored: *"I'm so proud when I see how many keywords I've got in BrainBank!"* one pupil said.

Some criticism has been raised by both pupils and teachers on the way hierarchical structures are built in BBL. Although BBL is related to the central ideas of concept mapping (a pedagogic method) as defined by Novak [16-18], it differs by the fact that it does not demand knowledge to be expressed hierarchical. On the contrary, with BBL a user can build and browse complex multi-directional associative structures, across context and disciplines. It is however quite possible to build hierarchical structures using the Topic Maps standard. Even within the standard itself, there is support for typing in a hierarchical manner. In the learning process, hierarchy and (not least) typing can be quite useful to understand structures and trees of concepts. For example, it is valuable knowledge in itself to know that 'cat' is a mammal. And as long as it is also known that mammal is an animal, 'cat' will have to be an animal, which represents even more knowledge. We will include ways to build hierarchic structures in upcoming versions of BBL by implementing *topic types*. Topic typing is an efficient way to express simple propositions like *cat is a (type of) mammal*.

In concept mapping, the idea of focus is essential [17]. There is always some kind of focus point where the mapping starts. Defining a context will always increase the value of information and knowledge. By somehow telling that a particular view of a piece of knowledge belongs to a particular context, it is easier to relate new chunks of knowledge to pre-acquired knowledge, and it is also easier to see the purpose of the knowledge in its current location. In addition, especially with young learners, it is important to be able to divide the knowledge into manageable chunks during the learning process. We will include a feature in BBL that makes it possible to create *themes*, and to use a theme to build a small knowledge map within the boundaries of the perspective. BBL is all the way centered on topics, and a theme can consist of one or more topics. As the learner acquires new knowledge and relates it to the theme, it makes sense right away, at least where it is put. Later on, as deeper understanding develops, the knowledge map belonging to the theme can be merged into the learner's main (complete) knowledge map. However, the theme is still kept as an identity to allow focused navigation, searching, etc.

Some pupils did complain that BBL is suffering from the lack of a powerful visualization of concepts and their relations. Numerous reports have documented the power of the concept mapping [19]. Implementation of graphical edition of concept map-like structures in BBL would thus substantially increase the value of the tool as a pedagogical method for meaningful learning. BBL has now implemented Ontopia's Vizigator™, a generic Topic Maps visualization tool developed by Ontopia [12], and we also intend to enable editing of such graphically visualized maps. Ontopia's Vizigator™ is based on TouchGraph's (http://touchgraph.sourceforge.net/) technology for visualizing map structures using Java Swing components. Another important strategy is to support, direct and/or indirect import/export from front end software for mind mapping and concept mapping. Interestingly, CmapTools [20] already supports XTM 1.0, and we believe that the concept mapping community should strive to decide on a common standard, preferentially XTM, for digital concept maps.

Successful learning often takes place within a sosio-cultural context where an interaction between humans is essential [21]. Interaction between the learner and the teacher is supported in BBL. However, cooperation between peers is widely accepted as a useful way of learning and some pupils did ask for such features. The ability to work in projects, where peers have equal access to all project resources is one attractive way of doing this. The project members should be able to share resources from their personal brainbanks with the project, as well as accept the project resources and import them into their brainbanks. Moreover, learners should be able to share knowledge maps and resources with the world by publishing them on public searchable web pages, free for anyone to browse. It is expected that this may help exchange of knowledge between peers. It is also important for the interaction between learner and teacher to have the ability to share resources. The teacher needs to be able to transmit resources to the learners. This could be possible in several ways, but as a principle, the learner should have to actively accept new resources. This is to ensure that the learner always is actively aware that he has received something new that can be used in his own knowledge structure. Furthermore, teachers should be able to share learning resources, from complete ontologies to simple learning objects, so that developed learning resources could be reused not only by the developer, but also colleagues and other teachers.

Research data indicates that the learners need curriculum and ontological support to responsibly record and manage their e-portfolios [4]. In an ongoing project, Dichev et al [8] aim to develop ontology-based courseware that supports learners in their reflection on knowledge, and that students can use to navigate and search course related material by broadly understood categories. With Topic Maps-based digital course libraries coming up [9], it will be very interesting to study how successful students can construct individual knowledge maps with predefined ontologies as a knowledge backbone. However, as helpful as it is to have good tools for individual learning, the world of information we live in is more and more based on networking and interaction with many instances and sources. The Internet is no doubt an important source for information, but the amount of information out there is so vast and overwhelming that new and better methods are needed to search and navigate. A useful point when trying to retrieve information from digital sources would be: What exactly is the learner's current knowledge in the area in question? Could we in some way analyze the learner's already acquired knowledge to help him locate new information that is relevant to him in his current position?

If representing the knowledge using a map like structure one could try to build some sort of mechanism that could analyze the documented knowledge and search the digital sources with the outcome of that analysis to determine what information that really is relevant. Leake et al. [22] have developed a model for this using concept maps. They used the locations and relations of the nodes in the concept map to automatically create queries for the Google internet search robot. As the hierarchical structure of a concept map supplies means to weigh concepts used in a semantic web search the new *Theme* feature in BBL can do a similar job. It gives a main topic (the perspective) that gives the boundaries for the scope. It is possible in the topic maps structure in BrainBank to start with one main topic and then count the radius: The distance from the main topic to other topics. This can also indicate a topic's level of relevance and it can help balancing the search and make it more accurate. However, because Google is not able to analyze what any retrieved page is actually *about* it is likely that such queries still would result in a lot of false positives. We are currently building a search function that automatically uses associations in BBL to focus the queries, and linguistic characterization and indexing to match the retrieved document content to the queries. Hopefully, this function will allow the users to spend less time on browsing and more time on learning.

Learning Strategies

BBL was designed to be a tool for meaningful learning [23] within a constructivist learning environment [24, 25]. The tool was inspired by the ideas of knowledge building developed by Joseph D. Novak and colleagues [26]: It stimulates the learning process as the learner continuously reflects through and updates his own knowledge and stores it in BrainBank. This is because he has to discriminate received information to extract the essence of the information to document it in BBL, and also by relating new information to already existing knowledge by associating new topics to existing ones and describing the relation between them [16, 17]. Some of the pupils said that they now pay more attention to *how* they are learning and made explicit statements that indicates that they have started a process of reflecting on their own learning process as such (e.g.: *"You become more aware of what you read when writing keywords: You pay more attention. When I do my homework more in-depth, because I'm going to find keywords."). One of* the main conclusion drawn by Bjørndal [14] is that BBL is a good learning strategy.

Assessment

Another important issue that came up during the project is how detailed and how often the teachers should evaluate the pupils. BBL opens for both formative and summative methods for evaluating students, which makes it a promising instrument for modern forms for education. Teachers and supervisors can at any time take a look at what their students and pupils has documented in BrainBank. This way, they both evaluate progress and the knowledge documented. By examining the associations the students have made between topics, the teacher gets an impression on how much the students really understand of the area of study as well. However, for the teacher this kind of detailed evaluation of many pupils is time consuming. Even if this challenge is not related directly to BBL (a teacher can simply choose not to use it for evaluation) the new options of assessment bring this issue out into the light. A possible answer to this could be to automate the analysis of the end product (*summative assessment*) by using techniques like latent semantic analysis [27] or by comparing topic maps: Several tools for comparing concept maps have been described [28, 29], but such systems are often restricted to particular subject domains, vocabularities and even map building environments. The Reasonable Fallible Analyzer [30] strives to be flexible in this respect: When comparing a map with any other map (for instance an expert map) it is honest and says it is likely to be wrong. The point is that the learner becomes aware of similarities and differences between different maps, and by arguing with the program, deeper understanding will be achieved. Results from a practical case [31] suggest that the Reasonable Fallible Analyzer is a promising tool *for formative self-assessment*, and at least with respect to time consumption a good alternative to *diagnostic assessment* done by the teachers with shortage of time.

Conclusion

As e-learning still strives to honor it's promises it is getting increasingly complex, partly because it deals with one of the most intricate disciplines in modern research: human cognition. Development and improvement of methods and techniques for handling different levels of granularity and use of networking needs to coincide with development of and commitment to standard ways of handling the increased complexity. These methods and techniques should be focused on the learners, rather than merely teacher-led. BrainBank Learning unleashes powerful support for learning, and it does so using a technological standard that is inherently fit for the purpose. There is a huge potential for improvements on several areas, such as peer cooperation, assessment and positioning. We will continue our mission and aim to develop these and others areas in close relation with learners and teachers and pedagogical and technical researchers.

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