

## **BRAINBANK LEARNING – BUILDING TOPIC MAPS-BASED E-PORTFOLIOS**

*Stian Lavik, MSc and Tommy W. Nordeng\*, PhD, Cerpus AS, Norway*

*\* Corresponding author: Address: N-8432 Alsvåg*

*Email: tommy@cerpus.com*

**Abstract.** BrainBank Learning (BBL) is a suite of intuitive tools for learning of concepts and their content, and how they relate. The core of the suite is BrainBank®, the ontology of a topic map for acquired knowledge in a lifelong perspective. Topic Maps is a standard that defines an effective way of representing information. BBL is a web-based topic maps editor that works with standard Internet browsers. This means that educational institutions are not dependent on local installations or state of the art equipment to use this computer aided learning software.

Users enter the application through individual accounts. Topics are entered and described and eventually connected to other topics as associations with names and/or descriptions. Digital resources such as documents, pictures, movies and sound clips can be attached to the topics, and these resources can either remain external and be linked to or be uploaded to and stored in BrainBank. Topics can be grouped in themes or courses (e.g. classes), but they can also be interconnected across subjects and levels/grades and can thus serve as a scaffold in lifelong and lifewide learning perspectives.

A research project with 8th grade pupils from in Norway has shown that in addition to the well-documented advantages of using concept-based tools in learning, the pupils became aware that they were actually building their own content/knowledge management system, and they were additionally motivated by this.

### **1 Introduction**

Today, humans need to cope with an increasing amount of information in most aspects of our lives. Not only are we overwhelmed with information, but also are the information and the channels through which we receive the information rapidly developing and changing. It is said that a person of today gets approximately the same amount of information in one edition of a newspaper as an average person would gather through his entire life in the Middle Ages.

There are at least two important factors that make the amount of information of today a real challenge: The work of discriminating information (to decide what to keep and what to ignore) and the process of transforming information to knowledge. As an attempt to assist these processes, the Norwegian company Cerpus AS has developed BrainBank Learning (BBL), a web based application that represents a systematic way of constructing and documenting knowledge during the learning process.

### **2 Background**

One of the major challenges when it comes to learning is to move the learnt material from short-term memory and into long-term memory. Probably one of the most widely used methods of achieving that, is to digest the information one have been exposed to in one way or another, e.g. by taking notes. While there are several benefits of taking notes, there are also (mostly practical) drawbacks. In addition to the relative coincidental nature of such notes, the work can often be experienced as boring and unnecessary (especially if the learner is a young pupil). The learner rarely visits such notes later on (for reflection) and even more importantly, it can be rather difficult to support the capability to see and document relations and associations by taking notes on paper.

If storing the “notes” in a digital format (with an useful and effective user interface), however, many of the above mentioned problems are already solved. Firstly, the information (“notes”) is can be stored and organized in a way that makes it easy to add new information and relate these to already existing information. Secondly, the stored information can be rearranged (re-organizing the structure of the information or for navigation and visualization) without having to re-enter it, and it is easily searchable. Thirdly, the possibility of making and representing associations between topics and subjects are much better when documenting digitally than when documenting on any static media (such as paper). The possibilities of storing massive amounts of information are also far better digitally than on paper or other static media. This last point makes it easier to gather documentation of knowledge from larger periods of time (or an entire lifespan) and to look back on previous knowledge and assess development.

There is another important aspect of documenting knowledge digitally, namely the possibilities for evaluation of the learner (especially important for teachers). If the students or pupils in a course or class document their learning digitally, it is possible to build solutions that enable teachers and supervisors to evaluate accurately. The assessment dimension is particularly promising if the digital production is organized and structured, e.g. as concepts maps [1].

Numerous computer-aided learning softwares 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, several projects in Norway illustrate the need for a way of organizing and systematically navigation in the information chaos. 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.

### **3 BBL**

BBL was designed to be a tool for meaningful learning [2] within a constructivist learning environment [3,4]. The tool was inspired by the ideas of knowledge building developed by Joseph D. Novak and colleagues [5]. Although the software has some similarities with concept mapping as defined by Novak [6-8], there are some clear differences: It is not hierarchical and it does not (yet) support a map-like graphical display of the knowledge structures. However, it is able to handle and store big and complex knowledge structures with attached digital content, and hence a powerful e-portfolio tool.

The first version of BrainBank was built as a simple web application with a database, (using WebObjects 5 from Apple). BBL of today is a web-based suite of intuitive tools for learning of concepts (topics) and their content, and how they relate. The core of the suite is BrainBank, the ontology of a topic map for acquired knowledge in a lifelong perspective. BBL is based on the Topic Maps standard (ISO 13250), including the XML format supporting the Topic Maps ISO standard (XTM) [9]. It was implemented using the Ontopia Knowledge Suite (by Ontopia, a leading topic map software vendor). BBL is currently hosted on a dedicated server, located and maintained at USIT (Centre for Information Technology), at the University of Oslo. As the Topic Map standard defines an effective way of representing information (through topics and associations etc.) [10], BBL now uses this Topic Maps technology to represent the data in the application. It is a web application that works with standard Internet browsers, which means that educational institutions are not dependent on any other local to use the application.

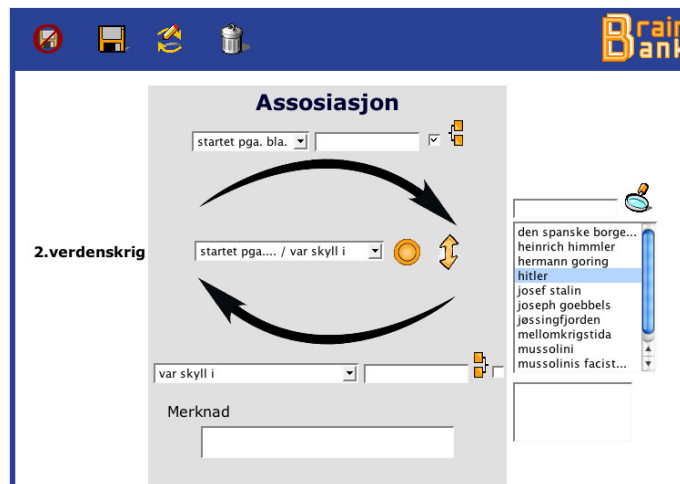
Users enter the application through individual accounts. Topics (keywords) that the learner meets during education activities are entered and described using BBL. The topics can then be connected by describing associations between them (Topic Maps provides excellent support for this). Thus the learner is creating his own associated network of topics and this represents his documented 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 (Figure 1).

To further describe topics and associations in BBL, 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).



**Figure 1** The edit topic page in BrainBank Learning. The figure shows an 8<sup>th</sup> grade pupil's associations to the concept *World War II* ('2.verdenskrig', in Norwegian). Beneath the topic's name, there is a text field to give a definition/description of the topic. At the lower half of this page, there are three tabs (the grey area). These tabs represent associations from the current topic to other topics ('Assosiasjoner' in Norwegian) (currently selected), attached resources to this topic ('Ressurser' in Norwegian) and comments that are sent between the learner and the teacher ('Kommentarer' in Norwegian). The tab for associations is selected, and we can see all the seven associations made from *World War II* to other topics listed here, grouped by association types. The first type is called *is category for* ('er kategori for'), and it says that *World War II* is used as a category for Mussolini, the political fascist parti Mussolini was leading, and Hitler. The rest of the associations similarly illustrate the relations between the current topic (*World War II*) and other topics. An important notion: If we were clicking the names of the topics that are listed on this association tab, we would be taken to the view/edit-page of that topic (and hence we would see the names of the associations in the other direction)

BBL 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 (Figure 2).



**Figure 2** The edit association page of BrainBank Learning. Here, the user can create/edit an association from one topic to another. To the left, we see the current topic, which is *World War II* ('2.verdenskrig' in Norwegian). To the right, 'Hitler' is chosen as target topic from a list of topics available in the learner's BrainBank. (If the desired topic is not in the list, the user can search for it within the complete pool of topics in his/her BrainBank, using the search field above the list). The grey area in the middle is where the real action goes on. The learner has chosen an association type to use to connect the two topics from the popup menu. This signifies a description of the association in both directions (note the black arrows). In this case, the labels chosen are *started, because of (among other reasons)* ('startet pga. bla.' in Norwegian) and *was responsible for* ('var skyld i' in Norwegian). In total, this gives the following meaning: *World WAR II - (was) started, because of - Hitler, and Hitler - was responsible for - World War II*. If no satisfactory association types can be found in the popup menus (all three are synchronized), the user can create a new one, by entering the desired descriptive text in the text fields above and below the black arrows. This new type will then be available from the list the next time the user enters this screen. There are two check boxes on this screen

as well, and checking these causes the topics to be categorized relative to each other (the direction of the categorization depends of course on which box is checked). Category is a special association type for constructing hierarchical knowledge structures.

The learning strategy represented by 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.

## **4 The BrainBank project**

The BrainBank project has been a cooperative effort between PLP (Program for learning and practical pedagogy) at the University of Tromsø, Cerpus AS, USIT (Centre for Information Technology) at the University of Oslo, and Alsvåg primary and secondary school. The project was financially supported by The Norwegian Ministry of Research and Education, The Governmental Office of Education at Nordland County and Apple Computer Norway.

### *4.1 Project goals*

The main goal for the 1<sup>st</sup> phase of the BrainBank project was to evaluate practical use of BBL and to find out if it helps improve learning to become more effective. It also aimed to discover how the learning process could be further improved.

Because of the short timeframe for this phase of the project, the focus has been on the learning process itself, more than on the outcome of the learning. It is hard to get any reliable results on how any specific method of learning will affect the learning outcome without conducting research over a long period of time (several years).

### *4.2 Test personnel and project timeframe*

The project group consisted of ten girls and six boys in 8<sup>th</sup> grade (approx. 13-14 years of age) at Alsvåg barne- og ungdomsskole (Alsvåg primary and secondary school). Two teachers were also a part of the project. The project is roughly divided into three phases<sup>1</sup> with a total time span of minimum six years. This paper presents the results from the first phase, going from July 1<sup>st</sup> 2002- July 15<sup>th</sup> 2003.

### *4.3 Project methodology*

The project was carried out along the lines of action research. Development and research have been tied up together in a common process, and this has colored the process in the project. A qualitative approach has been chosen, and these are the main activities used in the project:

- Observation of the project group (in their classroom)
- Observation of the pupils' brainbanks (in BBL)
- Interviews with teachers and pupils (individually and in groups)
- Questionnaire
- Informal conversations
- Written statements from the pupils

Some interviews, informal conversations and observation in the classroom were undertaken in the early stages of the project, but the main focus of the project activities was at the later stages of the project (when the pupils and teachers had had some time to learn how to use BBL, and had some experience from using it).

---

<sup>1</sup> Phase 1: 1 year time span, phase 2: 2 years, phase 3: several years.

## 5 Main findings

BBL has been used for individual work during teaching, individual work at the end of a lesson in class, individual in-depth studies, during group work and projects. BBL was found to work well within most educational methods, but some of the pupils (and the teachers) felt that they needed more time to work properly with BBL: 45 minute sessions were sometimes too short to acquire, digest and process the information, and then to document the new knowledge precisely as piece of the total knowledge map. These pupils asked for longer sessions.

### 5.1 Learning awareness

Initially, the pupils had problems coming up with a well-founded answer when asked to explain why they should use BrainBank. Neither were they able to write down satisfactory explanations of the key terms *keyword* and *category* from BrainBank. However, when some time had passed, observations of their work in BrainBank showed that in reality, they had gained quite a good understanding of the concepts of keywords and categories. With few exceptions, all of them had used both keywords and useful categories in BrainBank, even though they might not have been able to define them explicitly and independently of practical use.

In the later stages of the project, many of the pupils were able to formulate how BBL improved their learning. They had gained an explicit awareness of their own learning process. Based on the replies from the pupils (in interviews), especially two factors were identifiable; structure and order, and repetition of learnt material. Ten out of sixteen in the project group made statements related to structure and order. They felt it was better to structure and store the knowledge in BrainBank than on paper. (See Table 1 Statements from the pupils regarding reflection on the learning process.)

Pupils often think of repetition of learnt material as boring. Still, it is widely acknowledged that repetition is one of the best ways of *saving* knowledge. Seven out of the group of sixteen pupils said that BBL helped in remembering what they had learned. According to these pupils, BrainBank 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. The same pupils said that they regularly used BrainBank to repeat for themselves what they had learned (home or at school) (See Table 1 Statements from the pupils regarding reflection on the learning process.)

A third element that sticks out is that of awareness of learning. Some of the pupils say that they now pay more attention to *how* they are learning. The fact that the pupils had started reflecting on the structure of the learnt material and repetition in itself represent an improvement when it comes to how conscious the pupils are of their own learning. In addition, especially four pupils made explicit statements that clearly indicates that they have started a process of reflecting on their own learning process as such (See Table 1.)

All of these three main findings (structure, repetition and awareness of learning) are interesting to note in terms of using BrainBank to support and improve the learning process [6,7]. Here follows some of the pupils' self-expressed views on their own learning when using BrainBank (all translated from Norwegian, obviously).

<b>Structure and order:</b>
<i>"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."</i>
<b>Repetition:</b>
<i>"You kind of get a repetition of what is learned when typing it into BrainBank. When I'm in 9<sup>th</sup> grade, I can look back on what I learned in 8<sup>th</sup> grade."</i>
<b>Learning awareness:</b>
<i>"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."</i>
<i>"I have to read more concentrated to be able to make keywords and see associations."</i>
<i>"We have to really know the material. We can't just copy the book. We have to be more prepared for class. I do prepare better for class."</i>

Table 1 Statements from the pupils regarding reflection on the learning process.

## 5.2 Motivation

Pupils and teachers in the BrainBank Project express that they think BBL is an exciting tool that is easy to use and to learn. Here follows some quotes from the pupils to illustrate the pupils' enthusiasm for the new elements BrainBank represents (all translated from Norwegian):

<b>Motivation:</b>
<i>"I'm so proud when I see how many keywords I've got in BrainBank!"</i>
<i>"We think it's easier. Notes on paper can easily be lost or destroyed."</i>

Table 2 Statements from the pupils regarding motivation.

These statements (Table 2) are representative for the entire project group. One can raise the question if it is BBL that gives increased motivation among the pupils, or if it is simply the use of computers in general. Previous studies have reported that the use of ICT generally increases motivation. It is hard to separate the use of BBL from the use of computers in general with regards to motivation in such a short period of time as this first phase of the BrainBank project. But it might be an indication that almost all of the pupils expressed that they would like to use BBL in more subjects than the two picked for the project. Some even say that they would like to use BBL in all subjects, and that it would help them see connections between the subjects, e.g. languages etc.

## 5.3 Summary of the activity in BBL during the project

To summarize the activity among the pupils during the project, key numbers are presented in Table 4:

	<b>Number of topics (keywords) registered</b>	<b>Number of associations</b>
Low point	85	9
Average	225	38
High point	300	78

Table 3 Activity in BBL during the project.

As the table shows the number of associations is relatively low compared to the number of concepts. The most apparent reason is that BBL was used as a tool in "traditional" activities, and as the teachers did not focus on associations for all educated themes, the pupils were not always given time to build associative structures. Moreover, BBL as opposed to mind mapping and concept mapping software did not have a map-like graphical

interface. The lack of a good graphical visualization of the associations probably made it less apparent for the pupils why they should undergo the relatively time-consuming process of building a semantic associative map.

#### 5.4 Challenges

One issue that came up is how detailed and how often the teachers should evaluate the pupils. BBL offers possibilities of accurate and detailed evaluation, because of the teachers' possibility to look at the pupils' work. Since the pupils' work in BBL includes associations (and hence much of the pupils' understanding in the area of study), the teachers have the option of seeing how the pupils think of the relevant topics and their place in the context. However, for a teacher to do this kind of detailed evaluation of many pupils is time consuming. So, 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 automating this by using techniques like latent semantic analysis [11] or by comparing topic maps: If some pupil's topic map is widely apart from the other pupils and/or the teacher's, you may take this as signal to talk to the pupil.

### 6 Conclusion and the road ahead

The project concludes that 8<sup>th</sup> grade pupils are motivated by BBL and that BBL may stimulate meta-cognitive processes and reflective learning. Moreover, the results suggest that BBL is a promising strategy for associative learning and adapted education. BBL represents and supports a learning strategy that places the learner in the centre of the learning process. The idea is that the learner himself is (to a certain extent) building and documenting his own knowledge structure, centered on the actual content of the material he has worked with. According to the results from phase 1 of the BrainBank project, this strategy seems successful in several aspects. Previous experiments has shown that concept mapping tools facilitate meaningful learning and the creation of powerful knowledge frameworks that not only permit utilization of the knowledge in new contexts, but also retention of the knowledge for long periods of time [7,8]. In the ongoing follow-up study we will investigate more closely if similar results could be obtained without the map-like visualization.

Up till now (at least in Norway) much of the use of ICT in education and learning has been focused on the advantages of using digital media when it comes to communications, storing and motivation. There should be a greater focus ahead on developing systems that can help in *internalizing* the information available on the Internet (and other digital media) to build knowledge. Systems like BBL have several advantages in this picture. Firstly, when documenting knowledge in this tool, that documenting process helps the learning itself. Secondly, when the knowledge is documented, the system will work as a kind of personalized "encyclopedia" to the user. This lexicon is actually intuitive to navigate and search since everything is built on structures that user has made himself. In addition to that, as BBL of today (version 2.2) is using Topic Maps (and XTM) technology, navigation is made even more powerful (through associations etc.). Thirdly, in a larger perspective, if merging some of the users' topic maps, this kind of structure can represent the documentation of knowledge inside an organization or any other body.

Many issues for further research and development have appeared during this project. Several of those require a longer period of time to research than what the first phase of the BrainBank project offered. The following questions would be interesting to try to answer (through further research):

- How to ensure that BBL contributes to cooperative work between different subjects?
- How does BBL affect different ways of working, the learner's learning process and the outcome of the learning?
- How can the teacher most efficiently follow up on the individual learner's development through BBL?
- How can BBL best be used to aid the learners' reflection on their own learning?
- How can BBL best be used as a part of the learning habits of the learner, i.e. that the learner uses BBL on his own initiative?
- How can the teacher best guide the learners and help structuring of topics and associations in BBL?
- Would it help the learning process if the learners could explore and utilize directly each other's brainbanks?
- How can BBL best be used together with other e-learning resources (such as CmapTools, which already supports XTM 1.0, tools for building learning designs and e-curriculums, latent semantic analysis, learning management systems, etc.)?

To follow up all of these issues more time and resources is required. However, the issues reported here are good starting points for the continuance of the BrainBank project (further phases).

## 7 Acknowledgements

This Research Project was supported by a grant from the Norwegian Ministry of Education and Research. This paper is partly based upon an unpublished report from phase one of the BrainBank project, written by Kristin Emilie W. Bjørndal, University of Tromsø, Norway. We would like to thank Peter Sloep, Tore Hoel and Jarle R. Meløy for carefully reading the paper.

## References

1. J. Mintzes, Wandersee, J. & Novak, J. D. (2000) *Assessing Science Understanding*, Academic Press, San Diego.
2. D. P Ausubel. (1963) *The Psychology of Meaningful Verbal Learning*, Grune and Stratton, New York.
3. B. Wilson. (1996) *Constructivist learning environments: Case studies in instructional design*, Educational Technology Publications, New Jersey.
4. D. H. Jonassen & Rohrer-Murphy, L. (1999) Activity theory as a framework for designing constructivist learning environments, *Eduational Technology Research and Development*. 47, 61-79.
5. J. D. Novak. (1977) *A Theory of Education*, Cornell University Press, Ithaca, New York.
6. J. D. Novak. (1990) Concept maps and Vee diagrams: Two metacognitive tools for science and mathematics education, *Instructional Science*. 19, 29-52.
7. J. D. Novak. (1991) Clarify with concept maps, *The Science Teacher*. 58, 45-49.
8. J. D. Novak & Wandersee, J. (1991) *Special Issue on Concept Mapping*.
9. The Topic Maps.org Authoring Group. (2001) XML Topic Maps (XTM) 1.0. The Topic Maps Consortium in <http://www.topicmaps.org/xtm/index.html>
10. M. Biezunski, M., Bryan & R., Newcomb S. (1999) ISO/IEC 13250:2000 Topic Maps: Information Technology -- Document Description and Markup in <http://www.y12.doe.gov/sgml/sc34/document/0129.pdf>
11. T. Landauer, Foltz, P & Laham, D. (1998) An introduction to latent semantic analysis, *Discourse Processes*. 25, 259-284.