BrainBank Learning - building personal topic maps as a strategy for learning

Stian **Lavik** <stian@cerpus.com>

Tommy W. **Nordeng** <tommy@cerpus.com>

Jarle R. **Meløy** <jarle@cerpus.com>

Abstract

BBL (BrainBank Learning) 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 (ISO 13250) that defines an effective way of representing information. BBL is a web application (so called CAL - Computer Aided Learning - software), 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 the application.

Users enter the application through individual accounts. Topics (keywords) that the student meets during education activities are entered and described using BBL. The topics can then be connected by describing associations between them. 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 either be external or uploaded to and stored in BrainBank.

BBL stimulates the learning process as the student continuously reflects on and updates his own knowledge and stores it in BrainBank. The students can document their knowledge production in BBL. This opens up for new methods for evaluating students, and makes BBL an ideal instrument for modern forms for education.

With support from the Norwegian Ministry of Education and Research, a project to study the pedagogical potential of BBL has been undertaken at Alsvåg barne- og ungdomsskole with pupils from the 8th grade. The project has been evaluated by PLP (Program for learning and pedagogy) at the University of Tromsø, Norway. The main method for evaluation has been interviews with pupils and teachers, and the report presents several interesting pupil quotes: "we learn more", "we remember more of what we have learned", "we do our homework in a different way" are some examples.

The project concludes that BBL motivates the pupils, and stimulates a motivation for learning in the knowledge building process itself. A surprising finding was that it seems that BBL may stimulate meta cognitive process and consciousness of learning in such young pupils. Moreover, from a pedagogic point of view, the report concludes that the topic maps application BrainBank Learning is a promising strategy for associative learning and adapted education.

Table of Contents

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 the information and the channels through which we receive the information are also 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.

It is a challenge having to deal with this situation, for the society and for the individual. And especially in education it is a challenge to cope with exceeding amounts of information. When learning, one is trying to make the information become knowledge, and that requires even more efforts than merely taking in information from time to time. In the learning process it is important to be able to digest information and relate it to pre-acquired knowledge, for the new information to make sense in a relevant context. As Yadin Dubai puts it: "Bodies of knowledge in general are associative systems. Associations are not only aids to understanding, they are also proven mnemonic devices: The richer the associative network, the higher the probability that the item will be stored and retrieved" [Dubai, 2002].

In the picture drawn above, 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 making information become knowledge (by relating it to existing knowledge and placing it in the right context). To help these processes, the Norwegian company Cerpus AS has developed BrainBank Learning (BBL), a web based application that represents a systematic way of documenting the knowledge during the learning process.

2. Background

2.1. The Problem

It is easy for a learner to get lost in today's jungle of information. It is hard to navigate, and it is even harder to store and organise the large amounts of knowledge needed to cope with the rapid development in our surroundings in a way that makes it easy to remember what one has learned. And more and more often, people, companies and other bodies rely on information and knowledge one needs to retrieve from some kind of repository. So also with the learner.

Not everyone agrees on what is a satisfactory level of general knowledge. And now, more than ever, not just the information, but also the expected level of knowledge is rapidly changing in almost all aspects of life. Much knowledge that was gathered by the teachers of today (as they themselves studied) will be implicitly a part of the expected general

knowledge of tomorrow. Which also means that knowledge acquired is rapidly made obsolete by new information (often due to new technology and effective communications).

Students and pupils of today and tomorrow will have to acquire knowledge faster and faster. Therefore, many teachers, scientists and politicians over the last few years have pointed at the importance of being able to access and to use retrieved information in a meaningful manner. "To learn the learners how to learn", has become a way of speech.

However, despite the need for being capable of access and retrieve information, it is first and foremost already acquired knowledge that stimulates to search for new knowledge and to aspire for increased understanding. Hence, it is important for students to acquire a certain amount of basic knowledge to build further knowledge upon, no matter what. And it should be equally important for educational institutions to search for good instruments that can aid learning, not only projection of information.

2.2. How BrainBank Emerged

The idea about BrainBank and BrainBank Learning was born during studies. While doing his PhD, the student (at the time), Tommy W. Nordeng, realised that none of the software tools he tried to use to aid his learning process was quite suitable for organising and representing the knowledge accurately and effectively enough. There was a need of a better way to document the knowledge acquired, and also a way of being able to continuously build new knowledge based on this documentation. The software that was the offspring of these thoughts (BrainBank Learning) was meant to enable the learner to document his understanding of the acquired knowledge and to relate new knowledge to already existing (and documented) knowledge. The hope was for this tool to aid the users to remember what they learned better, and to become more reflected in terms of their own learning.

The concept of BrainBank fits well with both signals and plans coming from the Norwegian Ministry of Research and Education, and other important bodies in educational Norway, regarding the direction of education and e-learning in Norway, such as national plans for ICT in education etc. [Norwegian Ministry of Education and Research, 2003]. The timing was good, governmental funding for a project was available.

2.3. The Learning Process And How To Document Knowledge

One of the major challenges when it comes to learning is to move the learnt material from STM (short-term memory) and into LTM (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 organised 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-organising the structure of the information or for navigation and visualisation) 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 making the students or pupils in a class document their learning digitally, it is much easier to build solutions that makes it possible for teachers and supervisors to evaluate accurately. And not only evaluate accurately, but also give accurate and effective feedback.

All these (above mentioned) factors show that documenting the learning process and the knowledge digitally, clearly has great advantages for learners. If done in the right way, digital documentation of knowledge can also help the learners getting to know and understand their own learning better and hence develop their ability to learn.

Numerous tools (CAL software) exist to aid e-learning, web applications as well as offline systems. And the tools vary from customised learning applications to edutainment and simple communication systems. However, several projects in Norway illustrate the need for a way of organising and systematically navigation in the information chaos. A lot of 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. BrainBank Learning

As a response to the challenges described above, BrainBank Learning was developed. In addition to representing a method for digitally documentation of knowledge, it also offers a way for the learner of showing how he understands topics in their context (relation to other topics). This attempt to letting the learner document his understanding of a topic and not merely facts about one topic at the time is important in the learning process, especially if one wants the learner to reflect on his own learning and if one wants to be able to evaluate accurately.

The first version of BrainBank was built as a simple web application with a database, (using WebObjects 5 from Apple). This version was a part of the BrainBank project, a project that consisted of a project group (sixteen pupils in 8th grade, 13-14 years old) using BrainBank for a year, and academic evaluation of the project, conducted by PLP at the University of Tromsø, Norway.

An important outcome of the BrainBank projects first phase was thoughts on how to develop BrainBank further. As the initial version allowed the user to enter keywords with descriptions and to relate them together to create a kind of a semantic web representing the knowledge, there was discovered a need to emphasise the relationships between the keywords, and to technically base BrainBank on a technology that more naturally support the features needed. Thus, version 2 of BrainBank was built; this time based on the Topic Maps standard (ISO 13250), including the XML format supporting the Topic Maps ISO standard (XTM - XML Topic Maps) [The Topic Maps Authoring Group, 2001]. It was implemented using the OKS - Ontopia Knowledge Suite (by Ontopia, a leading topic map software vendor from Norway). BrainBank Learning is currently hosted on a dedicated server, located and maintained at USIT (Centre for Information Technology at the University of Oslo).

BrainBank Learning of today is a 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. As the Topic Map standard defines an effective way of representing information (through topics and associations etc.) [Biezunski et al., 1999], BrainBank Learning 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 local installations or state of the art equipment 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 BrainBank Learning. 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.

To further describe topics and associations in BrainBank Learning, 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).

BrainBank Learning 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 BrainBank Learning, and also by relating new information to already existing knowledge by associating new topics to existing ones (and describing the relation between them).

The learning strategy represented by BrainBank Learning opens up for new methods for evaluating students, and makes it an ideal 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 at the University of Tromsø, Cerpus AS, USIT, 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.

Some of the reasons for the project to become reality are that the methodology that makes up the foundation for BrainBank Learning fits with the goals of PLP and national plans for ICT in education at the time.

4.1. Project goals

The main goal for BrainBank Learning is to stimulate the learning process and so ultimately cause increased knowledge and understanding [Bjørndal, 2002]. This is achieved by giving the learner a good way of digesting and representing the knowledge he has acquired.

The main goal for the 1st phase of the BrainBank project was to evaluate how the use of BrainBank Learning affected the learning and the learning processes of the pupils in the project class, to see if it can help improving the learning effect. It was also aiming to discover how the learning process can 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 very 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).

Main goals for the project group (the pupils) have been:

- The pupils should get to know and learn how to use BrainBank Learning
- The pupils should understand the reasoning behind BrainBank Learning
- The teachers should get to know and learn how to use BrainBank Learning
- The teachers should try out different ways of using BrainBank Learning in the teaching

Main goals for PLP:

- Get to know the project parties and BrainBank Learning
- Supervise the project and evaluate to see if the project group reaches their goals
- Be able to give some kind of answer to the question: How does BrainBank Learning affect the pupils' learning process?
- Based on exploring observations and interviews, become able to give more precise formulations of potential further research and development of BrainBank Learning

4.2. Test personnel

The project group consisted of ten girls and six boys in 8th 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.

4.3. Project timeframe

The BrainBank project is roughly divided into four phases[1] with a total time span of minimum six years. This paper presents the results from the first phase, going from July 1st 2002- July 15th 2003.

4.4. 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 the process in the project has been coloured by this. 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 BrainBank Learning)
- Interviews with teachers and pupils (individually and in groups)
- Questionnaire
- Informal conversations
- Written statements from the pupils

For the project to work, it has been import to examine the pupils (and their learning) at early stages of the project, and then at later stages for comparison. Some interviews, informal conversations and observation in the classroom was undertaken in the early stages of the project, but the main focus of the project activities was in later stages of the project (when the pupils and teachers had had some time to learn how to use BrainBank Learning, and had some experience from using it).

Various ways of using BrainBank Learning have been tested in the project, both in individual work and in groups. One example is that the class were going on an excursion, and afterwards (as they returned) the pupils were told to reflect on what they had learned and to document it in BrainBank.

5. Main findings

BrainBank Learning 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. In advance, BrainBank Learning was expected to work well in individual work, but there was more uncertainty related to group work. However, it turned out that BrainBank Learning worked well in all the ways it was tried out (as mentioned above). Still, some of the pupils (and the teachers) said that it was too short a time to use BrainBank Learning in the last ten-fifteen minutes of the class. They felt that more time was needed to work properly with BrainBank Learning.

5.1. Consciousness of learning

Initially, the pupils had problems coming up with a well founded 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.

[1] Phase 1: 1 year time span, phase 2: 2 years, phase 3: 3 years, phase: several years.

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 be able to define them explicitly and independently of practical use.

In the later stages of the project, the many of the pupils were able to formulate how BrainBank Learning improved their learning. They had gained an explicit consciousness of their own learning process. Based on the replies from the pupils (in interviews) in March, 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.”.)

Many pupils think of repetition of learnt material as boring. Still, it is widely acknowledged that repetition is one of the best ways of making knowledge stick to the brain. Seven out of the group of sixteen pupils said that BrainBank Learning 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 consciousness 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, “Statements from the pupils regarding reflection on the learning process.”.)

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

Structure and order:
"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."
A pupil thinking of not continue to use BrainBank Learning next year puts it this way: "Everything would just have been a mess. I think it would be chaos up there" (pointing at her head).
Repetition:
"I'm so proud when I see how many keywords I've got in BrainBank!"
"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."
Consciousness of learning:
"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."
"In Norwegian (learning the language), there is a lot to remember. When I read Norwegian, I'm thinking about keywords. I read more concentrated, so that I can extract keywords."
"I have to read more concentrated to be able to make keywords and see associations."
"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."

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

These statements from the pupils (Table 1, “Statements from the pupils regarding reflection on the learning process.”) are interesting because they illustrate that the pupils have started to reflect on their own learning and learning process.

5.2. Motivation

Pupils and teachers in the BrainBank Project express that they think BrainBank Learning is an exciting tool that is easy to use and to learn. Based on classroom observation, group interviews, informal conversations, observations of the pupils' BrainBanks and written statements from the pupils, it seems that the project group has been highly motivated to use it throughout the project; even after the first wave of "novelty" enthusiasm had passed. Here follows some quotes from the pupils to illustrate the pupils' enthusiasm for the new elements BrainBank represents (all translated from Norwegian):

Motivation:
"Attending class has become more fun. We were to write down keywords on paper, and we all thought that was boring. It's better and a thousand times more fun to use a computer. You become more active when you're doing something that is fun instead of doing something boring."
"We're used to writing on paper, using a computer is something new and that makes it more fun."
"It's easy to go back and take a look at what we have learned."
"We think it's easier. Notes on paper can easily be lost or destroyed."
"We don't have to collect notes on paper, it's easier to find stuff."

Table 2. Statements from the pupils regarding motivation.

These statements (Table 2, “Statements from the pupils regarding motivation.”) are representative for the entire project group. One can raise the question if it is BrainBank Learning that gives increased motivation among the pupils, or if it is simply the use of computers in general. Previous studies of ICT in learning reports that the use of ICT in itself generally increases motivation [Turcato, 1998]. It is hard to separate the use of BrainBank Learning 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 BrainBank Learning in more subjects than the two picked for the project. Some even say that they would like to use BrainBank Learning in all subjects, and that it would help them see connections between the subjects, e.g. languages etc.

The two teachers in the project have also shown motivation for using BrainBank Learning. Both teachers and the headmaster have noticed enthusiasm and eagerness to learn among the pupils participating. The project seemed to have an overall positive effect on the learning environment for the pupils and teachers.

5.3. Positive effects for the project school

As mentioned above, the BrainBank project had some positive effects for the Alsvåg barne- og ungdomsskole (Alsvåg primary and secondary school), the school where the project was carried out. In addition to increasing motivation for the project group and the teachers, it helped the school acquire 18 new laptop computers, the school got broadband installed, and all the pupils participating in the project got increased knowledge on how to use computers in general.

5.4. Summary of the activity in BrainBank Learning during the project

To summarise the activity among the pupils during the project, key numbers are presented in Table 3:

Pupil	Number of topics (keywords) registered	Number of associations
Pupil 1	196	19
Pupil 2	180	19
Pupil 3	245	24
Pupil 4	249	43
Pupil 5	194	29
Pupil 6	198	44
Pupil 7	258	27
Pupil 8	249	82
Pupil 9	256	23
Pupil 10	175	50
Pupil 11	235	62
Pupil 12	85	12
Pupil 13	222	39
Pupil 14	300	9
Pupil 15	284	78
Pupil 16	270	46

Table 3. Activity in BrainBank Learning during the project.

As we can see from the table above, the number of keywords and associations registered in BrainBank varies quite a bit. This most likely reflects the natural variation among the pupils in terms of learning, in addition to possible variation in ability to use BrainBank Learning.

5.5. Challenges

Some challenges were uncovered during the project that should be focused on for further improvement of BrainBank Learning. The teachers experienced situations that raised some issues. The first one is how much time to use on BrainBank Learning. Some said that it was too short a time to use BrainBank Learning in the last ten-fifteen minutes of the class (as was sometimes tried). They felt that more time was needed to work properly with BrainBank Learning. This requires some thoughts on how to best integrate BrainBank Learning in the daily schoolwork.

Another issue that came up is how detailed and how often the teachers should evaluate the pupils. BrainBank Learning offers possibilities of accurate and detailed evaluation, because of the teachers' possibility to look at the pupils' work. Since the pupils' work in BrainBank Learning 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 really caused by BrainBank Learning, BrainBank Learning's possibilities of evaluation bring this issue out into the light.

6. Conclusion and the road ahead

The project concludes that BrainBank Learning motivates the pupils, and stimulates a motivation for learning in the knowledge building process in itself. A surprising finding was that it seems that BBL may stimulate meta cognitive process and learning consciousness in such young pupils. Moreover, from a pedagogic point of view, the report concludes

that the topic maps application BrainBank Learning is a promising strategy for associative learning and adapted education.

BrainBank Learning 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 degree) building his own knowledge and documenting that in his own digital structure, centred around the actual content of the material his has worked with. According to the results from phase one of the BrainBank project, this strategy seems successful in several aspects.

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 using the information available on the Internet (and other digital media) to build knowledge. Systems like BrainBank Learning 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 personalised "lexicon" to the user. This lexicon is actually easy to navigate and search, since everything is built around structures that are user made. In addition to that, as BrainBank Learning of today (version 2.2) is using Topic Maps (and XTM) technology, navigation is made even simpler (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 organisation 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 BrainBank Learning contributes to cooperative work between different subjects?
- How does BrainBank Learning 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 BrainBank Learning?
- How can BrainBank Learning best be used to aid the learners reflection on their own learning?
- How can BrainBank Learning best be used as apart of the learning habits of the learner, i.e. that the learner uses BrainBank Learning on his own initiative?
- How can the teacher best guide the learners and help structuring of topics and associations in BrainBank Learning?
- Would it help the learning process if the learners could see and explore each other's BrainBanks?
- How can BrainBank Learning best be used together with other e-learning systems (such as LMS (Learning Management System), etc.)?

All of these issues will need more time (and other resources) to research properly than what was available in the first phase of the BrainBank project. However, the issues mentioned here are good starting points for the continuance of the BrainBank project (further phases).

Acknowledgements

This paper was primarily authored by Stian Lavik. Much of it is based on the report from phase one of the BrainBank project, written by Kristin Emilie W. Bjørndal.

Bibliography

[Biezunski et al., 1999] *ISO/IEC 13250:2000 Topic Maps: Information Technology -- Document Description and Markup*, Biezunski M., Bryan M. & Newcomb S. R., 1999, http://www.y12.doe.gov/sgml/sc34/document/0129.pdfAccessed 19.02.2004.

[Bjørndal, 2002] *Sluttrapport fra prosjektet BrainBank ved Alsvåg barne- og ungdomsskole i Øksnes kommune (Report from the BrainBank project at Alsvåg primary and secondary school)*, Bjørndal K. E. W., 2002, http://cerpus.no/content/actual/publications/bb-project.pdfAccessed 19.02.2004.

[Dubai, 2002] *Memory from A to Z*, Dubai, Y., 2002, Oxford University Press.

[Norwegian Ministry of Education and Research, 2003] *ICT in Norwegian Education - Plan for 2000-2003*, Norwegian Ministry of Education and Research, 2003, http://odin.dep.no/archive/kufbilder/01/03/IKTiu005.pdfAccessed 03.09.2003.

[The Topic Maps Authoring Group, 2001] *XML Topic Maps (XTM) 1.0. The Topic Maps Consortium*, The Topic Maps.org Authoring Group, 2001, http://www.topicmaps.org/xtm/index.htmlAccessed 20.02.2004.

[Turcato, 1998] *I retning av en mer fleksibel skole; Suksesskriterier for IKT-bruk i skolen (Towards a more flexible school; Criteria for successful use of ICT in schools) (Norwegian only.)*, Turcato H., 1998, Kjeller, Norway: Telenor forskning og utvikling (FoU rapport 30/98).

Biography

Stian **Lavik**
CTO
Cerpus AS [http://cerpus.com]
Alsvåg
Nordland
Norway
stian@cerpus.com

Stian Lavik holds a MSc in Information Technology Management, and he is currently working as CTO for Cerpus AS.

Tommy W. **Nordeng**
CEO
Cerpus AS [http://cerpus.com]
Alsvåg
Nordland
Norway
tommy@cerpus.com

Tommy W. Nordeng (PhD) has a background as a researcher in natural sciences, and he is founder, owner and CEO of Cerpus AS.

Jarle R. **Meløy**
CRO
Cerpus AS [http://cerpus.com]
Alsvåg
Nordland

Norway
jarle@cerpus.com

Jarle R. Meløy has a background as a teacher and journalist, and he is co-founder, owner and CRO of Cerpus AS.