Collaborative On-line Concept Mapping

An initial project report submitted to The University of Manchester for the degree of MSc in Advanced Computer Science in the Faculty of Engineering and Physical Sciences

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Preface

In the last decade, research has explored new ways to support human learning, beyond the traditional methods used to date. Studies have shown that graphical methods such as concept mapping and mind mapping can be used to aid learning activities more effectively in contrast to other learning methods.

Research in both cognitive psychology and educational theory has shown that visual learning is one of the most innovative and effective ways to support organization of knowledge and human education. Concept mapping and mind mapping methods can be used to assist an individual or a group to make abstract ideas more visible and concrete, organise knowledge in an understandable visual way and connect prior knowledge with new concepts by utilizing a visual structure for planning and thinking.

Currently, interest in technology-supported learning (e-learning) has increased. The integration of Information and Communication Technologies (ICT) in education can be used as a lever for change towards creating a new more effective environment for learning (Commission, 2001). This project is concerned with the development of a collaborative concept mapping/mind mapping tool that can be used to aid the process of learning, provide a user-friendly environment where users can collaborate on and organise their ideas and thoughts. An analysis of the initial hypothesis – “development of a collaborative concept mapping/mind mapping tool to enhance learning” is made to gather project’s requirements. The project explores a technique for implementing the communication protocol to support this tool. Moreover, this project moves beyond the original scope by considering an ongoing project named Ketso (Ketso, 2008) and that project’s vision of developing a tool similar to the outcome of the proposed project.

Keywords
Computer based concept mapping/mind mapping, Concept mapping, Mind mapping, Education, Collaboration, eLearningMaps.
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Chapter 1: Introduction

Many educational psychologists based their studies on what has been called the "dual coding" theory of information storage. This theory, first suggested by Allan Paivio (1991, p.73), postulates that there are two forms of how knowledge is processed and stored in the human mind. These forms are distinguished by the way knowledge is presented; the two forms are the linguistic form where knowledge is presented verbally as words or statements and the imaginary form where knowledge is presented visually as mental pictures or physical sensations (Birbili, 2007).

Studies on how to communicate and educate people are moving beyond the traditional linguistic model towards a richer model that bonds visual representations with words. This approach arises from the simple adage that "A picture is worth a thousand words" (Fred R. Barnard, 1921). In our case the adage means that a visual representation of information (a picture) communicates complex relationships among concepts and stimulates critical thinking better than the traditional verbal representation (thousands of words). Tools based on this model have been proven more effective since they visually express the knowledge base of the learner, presenting ideas and concepts in a more understandable way. Additionally, this integration helps the learner to recall and remember information more easily (Birbili, 2007).

The fundamental nature of visual learning tools is based on this integration of linguistic and non-linguistic forms. Visual representations are supported by many tools (e.g., graphical organisers, pictographs) where the most common visual tool is the graphic organiser. Concept maps, Mind maps, Venn diagrams and others are some examples of graphic organisers. The importance of graphic organisers is significant since they help a human learner not only to understand information and see the relationships between ideas or concepts but also to organise and structure thoughts in a more readable and understandable way (Birbili, 2007).

This project focuses on concept maps and mind maps. Concept maps and mind maps are examples of graphical organisers based on the fundamental ideas set by Ausubel's assimilation theory (1964) and Deese's association theory (1965). Educational studies have shown that the human mind has the ability to organise knowledge in an orderly fashion. Knowledge is organised upon an existing framework or the learner's prior knowledge. When new ideas are presented to the learner, a framework of prior knowledge is constructed for the new ideas to attach to.

By utilizing the power of concept/mind maps and by presenting this framework of existing knowledge in a visual way, knowledge becomes much clearer. Concept and mind maps provide a powerful visual representation that relates new information to prior knowledge by depicting complex relationships and information (Ruffini, 2008).

This project is concerned with the development of an e-learning platform where concept and mind maps can be seen as the main components around which the various learning activities can be organised. Briefly, the project is concerned with the development of an application capable of constructing computer generated concept maps and mind maps. The primary objective of the project is the creation of a powerful e-learning and organisational tool that, in real time, will allow multiple peers to collaborate and visually display concepts, topics and the relationships between them.

1.1 Project Objectives

The main concern of this project is to investigate a new model of education based on a map-centred learning environment. The scope also includes the development of an e-learning tool that facilitates collaboration and distance learning. The broad objectives of this project arise by decomposing the Target Goal.
**Target goal:** Development of an online collaborative concept mapping / mind mapping tool.

Some of the broad objectives are:

- Investigate a new model of education based on a map-centred learning environment.
- Demonstrate an understanding of graphic organisers, specifically concept /mind maps.
- Analysis and design of an e-learning tool intended to be used by the (PEVE) Post Experience Vocational Education in Information Technology unit of the University of Manchester.
- Investigate and implement a communication protocol that will enable the real-time collaboration part of the project.
- Design and implement a software tool comprising a client component providing the user interface (UI) and a server component enabling collaboration between multiple client components.
- Investigate ways to enable the application to keep track of user changes (History feature).

The aims of this project are to produce an application to be used in the PEVE unit of the school, a tool that will enhance distance learning by minimising distance boundaries, ideal for both on-line tutorials and lecture sessions. Furthermore, the project aims to be used as a point of reference with regard to the implementation of the Ketso on-line project as described in Chapter 1.3 Beyond the Scope.

### 1.2 Scope

For a successful implementation of the objectives listed in Chapter 1.1, the scope of the project has to be clearly specified. This project’s scope includes the development of a real-time collaboration tool built on Java. The tool will allow multiple users to communicate and participate in real-time to the construction of a concept map/mind map. An innovative feature of the proposed application will be the History Tracker that will enable users to keep track of changes made on the map.

An ideal online collaboration tool could be used for both asynchronous and synchronous collaboration. Asynchronous collaboration would be useful when collaboration can happen at different times, where users do not need to coordinate one another and do not need to be notified of each peer’s changes in real-time (Edwards, 1997). This is useful when (1) users want to exploit time and space to work at their convenience without being restricted to any particular time schedule and (2) when they need a form of independence by working without the requirement of an internet connection.

However, for the purposes of this project synchronous collaboration is suitable since this project is concerned with the development of a real-time e-learning tool that, if well constructed, could be used to enhance distance learning due to several advantages (ability for multiple users to participate in real time, ability to monitor changes, facilitate participation, etc.)

In addition, the tool should be flexible in functionality by allowing the construction of both concept and mind maps. This will ensure the uniqueness of eLearningMaps since there is no other tool that can simulate both processes. For the mind mapping capability of the tool an adaptation to the Ketso methodology (ThinkingWare) is considered (refer to Chapter 4.1.1 Potential Collaboration for more details).

For clarity I will use the name eLearningMaps to refer to the proposed application.
1.3 Beyond the Scope

*Ketso* is a physical hands-on toolkit that is used to promote creative group work (Ketso, 2008) and which has been adapted to a variety of environments from business to education. Based on the idea of mind mapping, *Ketso* can be used to share ideas and knowledge as an alternative to traditional flip charts or paper notes. The *Ketso* project is working to develop an online version which will be analogous to their physical kit (Ketso, 2008). Due to the fact that there is an overlap between *Ketso*’s project and *eLearningMaps* an investigation is made on how a collaboration between the two projects can be feasible (refer to Chapter 4.1.1 Potential Collaboration for more details).

A first prototype of the *Ketso*-online software aims to enable the following capabilities:

- Input of data from a *Ketso* session into a virtual environment (virtual *Ketso* workspace).
- The capabilities to add, edit, move and join ideas on this virtual workspace in a manner directly analogous to the physical *Ketso* kit.
- Allow multiple peers to work simultaneously and/or asynchronously on the same “virtual workspace” over a network.
- Analyse and synthesise data from different sources.
- Be able to save and export data in an open format for integration with other tools and applications.

1.3 Report Structure

**Chapter 2 – Background and Initial research:** A literature review on concept maps and mind maps is made along with how e-learning can transform teaching. Methods on how to construct concept maps and mind maps are also discussed. The chapter concludes with a comparison of the two tools.

**Chapter 3 – Related work:** Strengths and weaknesses of the original concept mapping and mind mapping tools are discussed.

**Chapter 4 – Research Methods:** Explains the research methodology to be used for a successful outcome of this project along with a discussion of the tools and techniques for development. Also the chapter discusses and demonstrates an initial communication protocol that will be used as the basis during implementation.

**Appendix A:** A design idea for implementing *Ketso* mind maps.
**Appendix B:** Shows Initial Interface Design.
**Appendix C:** A Project Gantt chart used for planning.
Chapter 2: Background and Initial research

This chapter presents the research literature on the current theories behind graphical organisers such as concept maps and mind maps. Furthermore, it discusses the theoretical background on which eLearningMaps is based, introducing the terms concept map and mind map, how they are constructed, and how they can be utilized to enhance education. It further discusses how a concept/mind mapping tool can be blended for the creation of an e-learning tool that, by exploiting today’s technologies and the Internet, can be used to improve the quality of learning by promoting a new model for Education.

2.1 E-Learning

As contemporary education is changing and moving in different directions, educators and researchers are searching for more efficient ways to support human learning. Information and Communication Technologies (ICT) play an important role in changing the nature of how people learn. According to the European Community Commission, “E-learning is designing tomorrow’s education” (May 2000). In other words, the integration of new learning techniques with the use of today’s technologies will improve the quality of learning.

The integration of concept/mind maps in e-learning environments can be considered essential for transforming the way learning is done. The construction of concept maps and mind maps is moving beyond the traditional paper and pencil methods. With the ongoing development of ICT, various computer-assisted tools for concept mapping and mind mapping have been proposed with the ability to simplify the development of such maps. Tools such as iMindMaps or IHMC CmapTools discussed in Chapter 3, combine technological advances such as the Internet and the World Wide Web (WWW) with the strengths of concept mapping and mind mapping. Such software not only facilitates and improves the process of developing such maps but also promotes online collaboration, where multiple users can access and actively participate to the development of such maps.

2.2 Theoretical Framework

With the use of concept/mind maps a new paradigm of learning is promoted, one which is based on student-centred learning. This new paradigm offers to the student opportunities for individual exploration and self-learning. Graphical organisers such as concept maps and mind maps provide a powerful visual way to aid the learning process by integrating related existing knowledge with new knowledge, generating ideas through brainstorming, promoting self-evaluation and representing and communicating knowledge in a new way.

2.2.1 Concept Maps

In the literature, there are many identified methods for presenting and representing knowledge. Often knowledge and relationships among knowledge items are written in text, but other methods include graphs, charts and other visual methods. Concept mapping is one method of representing knowledge that incorporates visual and relationship information. Like road maps that show connections between cities, concept maps show how ideas are linked. Unlike road maps, concept maps also include relationship information and a hierarchy of the concepts presented.

Concept mapping is a visual representation technique that was developed by Joseph D. Novak as an outcome of his research group at Cornell University (1977). A concept map, illustrated in Figure 1, is a graphical representation of knowledge and is intended for describing concepts and their interrelationships in a form that, according to Jonassen et al., is close to how knowledge structures are stored in human minds (1993). Because of their visual way of presenting knowledge, concept
maps appear to be more effective in contrast to forms of knowledge representation such as pure text (Kremer, 1998).

Novak’s research was strongly influenced by two of Ausubel’s ideas on the Assimilation Theory of cognitive learning (Ausubel D. P., 1968; Ausubel, Novak, & Hanesian, 1978) as summarised below:

- Learning of new knowledge occurs most effectively if this new knowledge can be related to the learner’s framework of previous, existing knowledge.

- Semi-Hierarchical organisation of Concept Maps is influenced by Ausubel’s (1968) notion of subsumption: more general abstract concepts subsume more specific concepts. This theoretical notion allows organisation of more abstract concepts towards the top with the more detailed concepts arranged towards the bottom of the page (see Figure 1).

Concept maps promote a new way of thinking and learning known as Constructivist epistemology (Ausubel et al., 1978) which is based on the idea that individuals construct their own knowledge over time based on what they already know. The constructivist epistemology theory of learning is widely accepted and has a great influence in the current science of education which is moving away from the old claim that knowledge is derived from empirical observations.

Concept map learning techniques can be applied in a variety of settings ranging from the military to education where they have been used specifically as a self-evaluation or assessment tool. Such maps are used as a tool to improve learning and as an opportunity for the learner to organise and present externally his knowledge framework. Concept maps have been used in classroom settings in order to promote the spirit of collaboration among students (Canas, 2003). The use of concept maps is beneficial since it fosters student learning, organisation of knowledge and memorisation (Horton et al., 1993). Apart from the use of concept maps in education, concept mapping has been successfully used as a knowledge elicitation (KE) tool for producing models of domain knowledge (e.g., building ontologies) (Canas, 2003). Also, concept maps pertain to many business and industry environments when used as a brainstorming, organisation and knowledge-sharing tool. In addition military studies showed that concept mapping can be used effectively as a mission planning and organisation tool (see Golas et al., 1999, for a review of such studies).
In summary, concept maps are tools used for representing and organising knowledge by constructing a pictorial representation. Through brainstorming, one or more participants can create a map of some specific concept. Knowledge presented by the map can be easily comprehended by just observing the map and the relationships between the concepts. Both teachers and learners can benefit from the use of concept maps since the maps can assist in identifying and organising the key concepts on which a learning task is based (Novak & Gowin, 1984). Moreover, a concept map can be thought as a “snapshot” or a visual summary of current and prior knowledge. Figure 2 presents a concept map as a flowchart of ideas.

![Figure 2 – Concept map as a flow chart.](image)

**Construction Method for Concept Maps**

The human mind organises knowledge in small building blocks called **concepts**, and these concepts are then combined to form **propositions**. Concept maps are graphical tools used to organise concepts and form propositions in a similar way. Usually, **concepts** are enclosed in boxes or circles (see Figure 1). Visual symbols or icons can also be used for representing concepts. Interrelationships between those concepts are indicated by connected lines, called **links**. This relationship between linked concepts is specified by a **linking phrase**. Linking phrases are the joining mechanisms between concepts and are used to form meaningful propositions. The following table summarises the main building blocks of knowledge.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concept</strong></td>
<td>A perceived regularity in events or objects, or records of events or objects, designated by a word or a symbol (Novak &amp; Canas, 2008).</td>
</tr>
<tr>
<td><strong>Proposition</strong></td>
<td>Two or more concepts linked together to form a meaningful Statement (Novak &amp; Canas, 2008).</td>
</tr>
<tr>
<td><strong>Statement</strong></td>
<td>A unit of meaning (Novak &amp; Canas, 2008).</td>
</tr>
</tbody>
</table>

*Table 1 – Building blocks in knowledge.*

A variety of methods are used for the construction of concept maps. Which method is more preferable depends on the purpose of map construction (Canas, 2003). It seems that there is no right or wrong way of constructing a concept map. However, Novak and Gowin (1984) define a set of basic guidelines that can be followed for the construction of a concept map. The following table summarises these guidelines.
Table 2 – Steps for building a concept map.

<table>
<thead>
<tr>
<th>Brainstorming Phase</th>
<th>1. Start by defining the main topic, also called the focus question. Enclose this main topic in a circle or a box.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Once the main topic is defined, the next step is to identify and make a list of the most important concepts associated with the topic.</td>
</tr>
<tr>
<td>Organisation Phase</td>
<td>3. Next, decide the order of those concepts, going from the most abstract concepts to the most specific ones (top to bottom). Organise those concepts in the mapping workspace in a hierarchical arrangement.</td>
</tr>
<tr>
<td>Linking Phase</td>
<td>4. The next step is the addition of links to form an initial concept map.</td>
</tr>
<tr>
<td></td>
<td>5. Then relationships among the concepts are described by adding linking phrases to the map.</td>
</tr>
<tr>
<td></td>
<td>6. Once this is done, cross links, which link concepts from different areas or sub-domains of the map, are identified.</td>
</tr>
<tr>
<td>Finalizing Phase</td>
<td>7. For completeness, the map is reviewed to identify possible improvements or changes.</td>
</tr>
</tbody>
</table>

In order to practically understand the construction of a simple concept map, let’s consider our example as shown in Figure 1. We start by brainstorming, which will reveal out our main topic, here climate change. Once our main concept is defined, we list other concepts associated with the main topic before we know where they are going to go on the map. Next is the linking phase where we find relationships among concepts by connecting them with labelled lines. Finally, the map is reviewed and more relationships are revealed.

Benefits of Concept Mapping

In order to present the benefits of concept mapping let’s consider a scenario in which a student wants to understand and memorise text information for his final exams.

The classical method when a student wants to comprehend and organise information for a final exam is to study the information and take his notes on the side. Once the student understands the presented information he will use his notes to memorise the important ideas or concepts that arise from the text. However, this method is not as effective as constructing a concept map. By constructing a concept map no re-writing of existing text information is required. What is required is a collection of important keywords representing information. Those keywords will be used during the construction of the concept map. The student can start by developing an initial concept map of what he already knows and then he can build on top of that. That way the student can identify any weak points and he can visually see how he could relate new with old knowledge.

Among the many benefits of applying concept mapping to this simple scenario, a few principal benefits are:

- Helps the student to present previous knowledge on the subject and identify the student’s weak points.
- Information is memorised easily because it is organised using only important keywords.
- The learner is able use the map to extract relationships between keywords.
- Knowledge is broken down into simple and more easily understandable parts.
- Organises and presents information easily.
- Visually constructs a knowledge structure.
- Promotes creative thinking.
- Promotes self-directed learning.
Concept Mapping as a Collaborative Tool

Although the learning experience is considered an individual unique process that differs from individual to individual (Cicognani, 2000), concept mapping can be regarded as a powerful pedagogical process that fosters social creativity. When a student uses a collaborative concept map tool, the learning experience is promoted and becomes more effective when done collectively or within computer-supported collaborative environments (Davidson, 1998). The broad reason that learning becomes more effective is that methods like concept mapping engage the benefits from the interactions with others by blending their thoughts and experiences while trying to achieve understanding of a common concept of interest.

In concept mapping collaboration can be achieved in various phases when constructing a concept map. For example, in a brainstorming session (see Table 2) all participants can actively agree on the focus question and contribute in the creation of a list of keywords (Cicognani, 2000) that later will be used to give birth to the concept map. Collaboration is achieved among the group through evaluation, questioning, discussion and debate with others.

The proposed project, eLearningMaps, aims to make use of this collaborative nature of concept maps by developing a computer-based collaborative environment that promotes meaningful learning, and enables users to work collaboratively by allowing them to share their knowledge in real time. More details regarding the features and requirements of eLearningMaps are discussed in Chapter 1.1 Project Objectives.

2.2.2 Mind Maps

Note taking can sometimes get out of hand when researching a subject because one can end up with scribbles that are more confusing than useful (MindTools, 2010). On the other hand, making a mind map instead of scribbles or a draft list of ideas is a more productive way to organise thoughts and ideas. According to Tony Buzan (1995) a mind map is a powerful thinking tool which can be used to externally reflect thoughts and ideas stored in the human mind. Mind maps are pictorial representations where ideas and pictures are organised around a general theme using a radiant hierarchy, like an organic tree with branches flowing out from the general theme (see Figure 3). In order to stimulate visual abilities and enhance memory recall, mind maps are typically formed using a combination of colours, words and drawings.

Mind maps are a tool with huge potential; they can be used to improve understanding, encourage creativity and flexibility, brainstorming, planning and problem solving. The two-dimensional structure of mind maps allows one to see the shape of a structure and how important points relate to each other.

![Figure 3 – A mind map example (Genovese, 2009).](image-url)
Construction Method for Mind Maps

Mind mapping is a useful tool that can help information management by allowing a map creator or reader to structure, organise, arrange, brainstorm and learn information more effectively using a visual mapping methodology. The process for drawing a mind map is very simple; the following snippet illustrates the broad steps used for the construction of a mind map.

The radiant structure of mind maps is similar to an organic tree. A main topic is defined and the map is expanded outwards by adding sub-topics which are related to the main topic. The outcome of a Mind map encompasses a radiant structure which is similar to the way mind stores information (Buzan & Buzan, 1996). In his book *The Mind Map Book*, Buzan describes a set of best practise guidelines for constructing a mind map that could be used to improve the constructing methodology as well as the information contained within the mind map (1991).

| 1. | Start in the centre by defining the map’s general theme and draw a memorable image that represents the main topic (Use at least 3 colours). |
| 2. | Use images, symbols and dimensions when designing the mind map. |
| 3. | Select keywords and print them using upper / lower case letters. |
| 4. | Each word or symbol must sit alone on its own curved line. |
| 5. | All curved lines must branch out from the central image. (Use different colour to represent each line). Curve lines are organic and free flowing. |
| 6. | Draw additional branches as extensions from main branches (represent sub-topics). |
| 7. | Keep expanding outwards by adding sub sub-topics (keywords and branches). |
| 8. | Use consistent colours throughout the mind map. |
| 9. | Use emphasis and show associations throughout the mind map. |
| 10. | Use a Radiant hierarchy and keep the mind map clear. |

*Table 3 – Key steps for creating mind maps (Buzan, 1996).*
Mind Mapping as a Collaborative Tool

Mind mapping is a technique with huge potential and a wide range of possible applications. Because of their unique structure and incorporation of images, mind maps allow one to see the structure of a subject and associations between topics. Hence, mind maps are ideal for: (1) reviewing information quickly and efficiently; (2) categorizing and organising information; (3) improving memorisation of information; (4) improving creative problem solving (Buzan, 1995). Mind mapping works well in a collaborative environment when used as a tool for brainstorming and sharing ideas with others. Using a mind map, all members can focus on one topic and visually represent their thoughts. Finally, mind maps can be used as a note-taking tool to record important decisions or even summarise a meeting and as a planning tool for a group project.

Concept Maps and Mind Maps – a Comparison

Concept and mind map techniques arise from relevant theoretical ideas and research in the field of graphic knowledge representation tools. As graphical organisers, both concept maps and mind maps aim to improve knowledge management. Despite the apparent similarity of concept maps and mind maps as diagrammatic tools used to visually represent mental models and to organise knowledge, these two kinds of maps have several dissimilarities. A brief comparison of their definitions allows us to reveal their broad differences. A concept map describes a network of concepts that are linked together to form propositions, with the central main concept at the top level and various sub-concepts networked down from that main concept (Budd, 2003). On the other hand, mind maps are organised around a general theme using a radiant hierarchy, like an organic tree with branches flowing out from the general theme.

The first difference comes directly from the way those maps are structured. Mind maps have only one main concept and other ideas are organised forming a radiant hierarchy. That is, a central idea branches off in many directions where branches break down into more detail, just like a tree. While in a concept map a network hierarchy of more than one main concept is constructed.

Ralph Haber and other researchers focus their research on memory improvement and memorization by using images. They have concluded that the use of icons, colours and images are more stimulating and promote better memorization than pure text (1960). A noticeable difference is that mind maps (see Figure 3) emphasise to higher degree the use of colours and images to enhance the map, whereas concept maps (see Figure 1) rely less on colours and images. Furthermore, mind mapping intends to be more personal and to aid brainstorming whereas concept mapping introduces a new pedagogical function that aims to present and relate knowledge in an understandable way to students.

Finally, the fundamental aspects of these two mapping techniques show their different ideas. Concept mapping techniques are based on the theories of David Ausubel (1968) who stressed the importance that the learning of new concepts requires a framework of prior knowledge. Concept maps are used to structure this knowledge. On the other hand, mind mapping harnesses a structure like the way the brain uses to represent knowledge. According to Buzan (1995) the brain is radiant and “it thinks centrally and explodes out in all directions”. This multi-direction radial representation of knowledge is captured by mind maps.
2.3 Conclusion

It can be argued that concept mapping begins where mind mapping finishes, from one side of the coin mind maps can be used to help us represent our thoughts in a more personal way, whereas on the other side, concept maps attempt to produce an abstract model of the main concept, from thoughts captured by a mind map, while focusing on the relationships between concepts. However, both concept and mind mapping are based on previous theoretical justifications. Their intention is to introduce a new way of thinking and learning by introducing a new pedagogical model and serving as a method for brainstorming and presenting meaningful information.
Chapter 3: Related Work

Today there are many visual mapping applications that assist the concept and mind mapping process. Due to space limitations, this project’s related work discussion is constrained to Buzan’s iMindMap, as an example of a mind mapping tool, and to CmapTools developed by the Institute of Human and Machine Cognition (IHMC), as an example of a concept mapping tool.

3.1 Mind Maps

3.1.1 iMindMap

The most well known mind-mapping software is called iMindMap (Tsinakos & Balafoutis, 2009) launched by Tony Buzan’s organisation. Although there are several computer-based mind-mapping tools, iMindMap is the tool that duplicates the original process and organic mind mapping method introduced by the company’s founder Tony Buzan. The iMindMap software tool captures the mind mapping process on a computer and allows the creation of mind maps as one would do on paper. The software runs on MS Windows, Linux and Mac platforms offering a user-friendly interface that allows users to draw freehand organic branches using a mouse, keyboard or a computer pen.

A great feature of iMindMap is that it allows images, colours and sound to be integrated onto a mind map, helping people to transfer their thoughts onto the map more accurately. There is less emphasis on being able to collaborate or share maps online, which some other mind mapping software like MindMeister or XMind are aiming at. iMindMap may suffer from a lack of an online collaborative environment for mind mapping but its export feature has been wisely developed with a variety of export options (e.g., PDF, SVG, XLS, DOC etc.) (Tsinakos & Balafoutis, 2009). This allows sharing maps with other mind mapping software including top market leaders such as MindManager and ConceptDraw.

The E-Learning Course creation module is one of iMindMap’s innovative features. The module allows the production of teaching courses that incorporate visual content, audio and animation and delivers them electronically. Other features of iMindMap are multilanguage support, its unique way of representing mind maps and its integrated image/icon library.

Although iMindMap serves well as a powerful communication tool by offering easy-to-use software for constructing mind maps for creative thinking, organizing ideas, project planning and brainstorming, it still lacks online collaboration capabilities and the ability to share maps online.

3.2 Concept Maps

3.2.1 CmapTools

Developed at the Institute of Human and Machine Cognition (IHMC), CmapTools (Cañas et al., 2004) offers a software suite that bridges the gap between today’s internet technologies and computer generated concept mapping. CmapTools is a Java-based concept mapping tool used to facilitate the construction and sharing of Concept Maps (Proctor & Vu, 2005). The software is available for free for non-commercial use and is machine independent since it is developed in Java.

The tool offers a WYSIWYG interface that allows users to construct concept maps. Through drag-and-drop, the software allows the user to insert videos, images, web pages or other visual material into a concept map.

An innovative feature of CmapTools is the synchronous collaboration offered, which, unlike iMindMap, allows multiple users to view or change a map in real time. The tool not only allows users
to collaborate, it allows them to make their maps publicly available over the Internet, search for material over the web to enhance the content of their maps and link to various online resources (Novak & Canas, 2008).

3.3 Synopsis

In this chapter a discussion of the most well-known concept mapping and mind mapping tools has been made, along with an identification of their strengths and weaknesses. The tools discussed are considered to be the leading products in their respective fields, but many lack important features that this project addresses, such as real-time collaboration and change tracking. There is a need for a hybrid tool that can assist the construction of both concept maps and mind maps, a tool that emphasises online collaboration features for real-time collaborative construction of both map types.
Chapter 4: Research Methods

4.1 Project Overview

The methodology flow to be used for this project is divided into three broad phases as outlined below and illustrated in Figure 5.

- **Phase 1:** Includes a literature review along with analysis of critical points and existing knowledge of the problem under investigation. In the context of the proposed project, the literature review was valuable for creating a broad familiarization regarding the topic. Additionally, in Chapter 2 Background an investigation of current software solutions that aid construction of concept maps and mind maps was made. This phase is completed with the submission of this “Project Background Report”.

- **Phase 2:** The findings from **Phase 1** will be used as the basis for the design and implementation of the desired software. Once a thorough understanding of the literature is achieved, the project will enter the **Requirements Gathering Phase** where the functional requirements of the system are determined. Next, the System Design Phase builds a detailed conceptual description that will influence the implementation. Various candidate architectures for the Communication Protocol, based on the initial architecture as described in Chapter 4.2.1 Communication protocol: Initial Design, will be studied, improved and implemented along with all other requirements. An Iterative and Evolutionary approach as described in Chapter 4.4.1 Iterative and Evolutionary Development will be used for implementing this project, translating the conceptual design to the actual programming language that will be employed for the project. The final step of this phase will include extensive testing to ensure that the application is working at an acceptable level. Briefly, Phase 2 attempts to answer the following broad questions:

  - What are the design goals and requirements?
  - How to develop the communication protocol?
  - What security aspects need to be considered?
  - How to tackle the implementation phase of the project?
  - How can the Ketso project benefit from this implementation?

The outcome of this project will be a fully functional online collaborative tool that will assist in the construction of concept maps and mind maps. In addition to the synchronous drawing capabilities of the software, a feature that will keep track of what changes have been made on the map will be implemented.

- **Phase 3:** This is the final phase of the project which is concerned with writing of the Thesis. The paper will present a research portfolio and conclusions drawn from the project, a summary of the contributions made and a prospect for future research. Also all design and implementation decisions will be presented.
4.1.1 Potential Collaboration

Collaboration with the Ketso project is considered, due to similarities of the two projects. Both projects are concerned with the development of a platform-independent collaborative tool that will aid the process of constructing concept maps and mind maps. Ketso design thought, is much closer to a mind map structure rather than a concept map. The eLearningMaps project is concerned with the development of a “hybrid” tool that will allow users to create both a concept and a mind map structure, depending on their preference. Because Ketso utilizes a clear and well thought-out methodology for creating mind maps consideration is made to encompass this methodology with eLearningMaps. The eLearningMaps use of Ketso methodology could prove beneficial for Ketso since the software will adhere to the requirements for a Ketso prototype that will simulate the process of a Ketso session.

In addition other ideas from Ketso can be incorporated and blended with this project, such as Ketso’s unique look, feel and graphics (e.g., coloured leaves). Also Ketso’s ThinkingWare methodology – the structured guidance to achieve the desired objectives of a Ketso session – which are used for effective collaborative thinking, can be simulated by eLearningMaps.

4.2 Initial Specifications

4.2.1 Communication Protocol: Initial Design

Initial research on how the collaboration part of the project can be implemented showed that the use of a Java socket API is appropriate. Phase 2, product implementation will include a more in-depth analysis of this technical aspect.

The communication protocol of the application will consist of two components, the client component and the server component. There is no need to setup a dedicated server to support this application since users will only need the client component. The server component will only be responsible for starting connections between clients (peer-to-peer). When a connection is established then the server will step aside and wait for another request from a client that requests a connection. In addition the server will hold information regarding the details of each client (i.e. userid, port, remote name) within the network, along with historical data that will be used for the implementation of the history feature.

Figure 6 shows a visual representation of the protocol. Prior to any connection request, each client must register with the system, where the server component will be responsible for maintaining a data file with the details of each of the clients. When Client 1 requests a connection with another client (assume Client 2), Client 1 must contact the server, then the server checks the database for Client 2’s details (port, remote address etc.). If Client 2 is online, the server sends a message to inform Client 2 that some other client wants to establish a connection. Client 2 then will have the choice to accept or reject the connection. When Client 2 accepts a connection Client 2’s receiving port and address will be sent directly to Client 1. A connection will be established directly between the two clients thus reducing the load on the server. Because a client will have a multithreaded interface, it will be able to communicate simultaneously with many clients. Figure 6 summarises the process.

Once this initial connection is established, Client 1 (who initiated the group) should be able to extend this one-to-one meeting to a group meeting by inviting more people to join the conversation. Again the group invitation should be sent to the server component. The server component will distribute the request along with a list containing details (ports, addresses) of existing group members. The server checks the database for the target user(s) and forwards the request from Client 1. If the user(s) agree to talk with the rest of the group then a new thread will start, containing a list with
existing group members. The thread will then start sending messages directly to the other group members. Upon receipt of this message, each member of the group adds the newcomers’ information to their list.

![Diagram of Initial Communication Protocol]

*Figure 6 – Initial Communication Protocol.*

4.2.2 Development Tools

The following sub-section briefly describes the tools that will lead to a successful outcome of the project.

**Java & Java2D API**

The Java2D API offers a complete package to develop high quality graphics for Java applications. For developing a tool to aid the construction of computer generated concept maps and mind maps, such graphics support is needed, and this is where Java2D fits nicely into the project. Among its functionalities, Java2D offers support for the creation of arbitrary geometrical shapes that will be used for the creation of our concept and mind maps.

*With a range of programming languages out there, why the choice of Java?*

An important criterion for using Java is that *eLearningMaps* is not concerned with the development of a web application that will be hosted in a browser-controlled environment, so Java was the right choice among other languages such as PHP and Ruby on Rails that rely on a web server. The easy-to-use, network communication model that Java offers, the well structured object-oriented and organised logic behind Java, the documentation available online, the wide range of books and tutorials associated with Java2D, the high quality of graphic capabilities and my experience with the Java platform led me to choose Java as the programming language that will lead to a successful completion of this project.

Furthermore, the *eLearningMaps* project aims to develop an open-source application, a package that can be used as an independent API to contribute to and receive development from other users and projects such as *Ketso*. The choice of Java with its object-oriented nature will fulfil this requirement and offer the modularity in development that is sought.
NetBeans IDE

The NetBeans platform is an integrated development environment (IDE) used for developing applications (Sun, 2009). NetBeans offers the opportunity to a developer to work with various programming languages such as C/C++, PHP, Ruby but is most popular for developing Java applications. For a reasonably large project like eLearningMaps, a modern development environment like NetBeans is essential for the good organisation and debugging of the code. NetBeans is extensible and can easily integrate new libraries that expand its functionalities. Also it offers a powerful simple editor for Java that provides smart code completion, Java API documentation and debugging. These features will accelerate the project’s implementation process of the project.

During the development stages of the project, the NetBeans GUI functionality can be used for the design of the prototype GUI, saving time that can be used for the more challenging programming sections. Overall, NetBeans contributes to the production of high quality code and will help overcome various issues raised during the development phase such as code debugging and GUI design.

4.3 Criteria for Success

This project will be characterised as successful if all phases as described in Chapter 4.1 Project Overview are fully completed within the allocated time. Specifically regarding the implementation part of the project, success will be characterised by successful design, analysis, development and testing of the application, including completion of the Target Goal. The research element of this project will be evaluated by the quality of the findings such as scientific articles, books and electronic resources regarding the research theme of this project. Proof of understanding the literature and wider research is presented in this Project Background report and a deeper understanding of the overall research will be presented in the final thesis. This final part of the project – Thesis Writing – will follow the University guidelines and regulations. As the final component, Thesis Writing is important because it will document all the research and conclusions along with the eLearningMaps implementation details. Overall the Thesis will provide evidence of a successful completion of the project.

Survey

The ideal case for testing and evaluating the project work and the resulting eLearningMaps software will be to gather feedback from students regarding the usefulness and potential of the tool from their perspective. Also questionnaires will accompany the testing so that notes and feedback from testing can be recorded and used in future improvements of the application. Efforts will be made to collaborate with the Ketso development team for evaluating the project. Also PEVEIr members could evaluate the tool by using it and providing feedback.
4.4 Organisation of Work

The first step of the project is to plan and establish solid project organisation which will lead to a successful outcome. Good organisation means clearly establishing the objectives and timeframe of the project.

4.4.1 Iterative and Evolutionary Development

The eLearningMaps software will be developed using an Iterative and Incremental approach. This software engineering approach is based on a very simple idea that has proven effective for projects with ongoing or open-ended development. Using this approach, development is performed through a series of mini projects called Iterations, each Iteration has its own development life cycle which tackles only a part of the actual requirements. This evolutionary process benefits from early risk management since each prototype is tested before integration with the core system.

The implementation part of this project will proceed through the following three stages:

**Stage 1**: Tackle the requirements arising from the Target Goal (refer to Chapter 1.1 Project Objectives).

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A tool for developing concept/mind maps.</td>
</tr>
<tr>
<td>2.</td>
<td>Share maps with others.</td>
</tr>
<tr>
<td>3.</td>
<td>Multiple users collaborate online.</td>
</tr>
<tr>
<td>4.</td>
<td>Be able to save a map.</td>
</tr>
<tr>
<td>5.</td>
<td>Open the same map and work at real time</td>
</tr>
<tr>
<td>6.</td>
<td>A function to keep track of user changes (History Tracker).</td>
</tr>
<tr>
<td>7.</td>
<td>Be able to add notes/comments to maps.</td>
</tr>
<tr>
<td>8.</td>
<td>Insert images/ Link to images.</td>
</tr>
<tr>
<td>9.</td>
<td>Link a concept map with another concept map.</td>
</tr>
</tbody>
</table>

*Table 4 – Summary of Requirements.*

Stage 1 includes the development of a cross-platform application where the user will be able to draw concept maps and mind maps. In addition, the user will be able to collaborate in map development with other users online. Any created map will be retrievable at any time for additional editing or reviewing. Furthermore, a history feature will enable users to keep track of changes that have been made to the map by other people. *Table 5 – Initial Iterations*, summarises possible initial iterations that will initiate the implementation phase of the project.

<table>
<thead>
<tr>
<th>Initial Iterations</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Investigate suitable Network Protocol</strong></td>
<td></td>
</tr>
<tr>
<td>A.1 Research</td>
<td>1 week</td>
</tr>
<tr>
<td>A.2 Decompose design goal</td>
<td>1 day</td>
</tr>
<tr>
<td>A.3 Coding phase</td>
<td>1 week</td>
</tr>
<tr>
<td>A.4 Debug &amp; test</td>
<td>3 days</td>
</tr>
<tr>
<td><strong>B. Initial GUI design</strong></td>
<td></td>
</tr>
<tr>
<td>B.1 Research</td>
<td>3 days</td>
</tr>
<tr>
<td>B.2 Decompose design goal</td>
<td>1 day</td>
</tr>
<tr>
<td>B.3 Coding phase</td>
<td>3 days</td>
</tr>
<tr>
<td>B.4 Debug &amp; test</td>
<td>2 days</td>
</tr>
</tbody>
</table>

*Table 5 – Possible Initial Iterations.*
Stage 2: Extra requirements.

Stage 2 includes the implementation of the extra requirements as specified in Table 6 – Extra requirements or any other requirements that may be needed to make this tool more functional and effective.

<table>
<thead>
<tr>
<th>No.</th>
<th>Extra Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A chat room where users can chat while constructing a map.</td>
</tr>
<tr>
<td>2.</td>
<td>User can create a draft map prior sharing it with others.</td>
</tr>
<tr>
<td>3.</td>
<td>Export maps to various file formats (Pdf, png).</td>
</tr>
</tbody>
</table>

Table 6 – Extra requirements.

Stage 3: Future Development.

The ongoing development of this project has the potential to be the largest part. As this project moves beyond the initial goals, the software may be transformed into an application where users can represent knowledge using a 3D visual environment. Instead of exclusively using the traditional notes and arcs as the building blocks of concept/mind maps, users could represent knowledge using 3D geometrical objects. In addition, further research could focus on developing a textual knowledge representation language that can express those maps. Eliminating ambiguity in such a language could be the challenging part.

This project can move beyond the development of a traditional concept/mind mapping tool. However the main target of this project is to develop an application that fulfils the requirements as specified by the MSc project as mentioned in Table 4 – Summary of Requirements. Also, within the time constraints, efforts will be made to implement some of the extra requirements mentioned in Table 6.

4.4.2 Project Plan

The planning of this project started as soon as the Project Allocation phase of the University ended at the beginning of February. Initially the project began with extensive research to reach a core familiarity with the subject material (approximately 30 days needed). Additional time was then allocated towards researching of the wider context and uses of concept maps and mind maps (10 days). Also, time was spent studying various existing tools in order to identify their capabilities and weaknesses (6 days). Once enough research was achieved, a draft plan structure of this report was presented to the supervisor for discussion and approval (2 days). This initial structure was important for the writing of this report (completed in 20 days). All the above steps were essential for successfully completing Phase 1 of the research methodology as described in Chapter 4.1 Project Review.

The project’s next step is the implementation of an early prototype of eLearningMaps consisting of the initial Iterations as described in Chapter 4.4.1 Iterative and Evolutionary Development; Communication Protocol and GUI. The task is estimated to take up to 2 weeks to fully implement and test the prototype. Research and familiarisation with the Java Socket API is essential so some time is allocated for this task as well. As soon as the initial iterations are complete then the development will proceed with implementing the Client Component and Server Component (refer to Chapter 4.2.1 Communication Protocol: Initial Design for more details). Upon completion of the project sufficient time will be allocated for testing and evaluation, for more on how the evaluation will be conducted refer to Chapter 4.3 Criteria for Success.

For additional information regarding tasks and time allocation, a Gantt chart of the project is available in Appendix C of this report.
Chapter 5: Summary

Although the learning experience is changing with the help of new technologies, still much research needs to be done before drawing any conclusions on whether online learning environments can effectively replace traditional educational methods (Cicognani, 2000). However, research supports the notion that online educational environments for concept and mind mapping can support education and provide solutions to some of the problems of traditional learning models. First, such mapping techniques adopt a new way of learning and thinking where students are the principal actors in the organisation of the learning activities, and second, such mapping techniques promote collaboration among students in an effective way.

Why collaborative learning? Graphical organisers like concept maps and mind maps shift learning from the traditional teacher-centred environment to a more collaborative learning environment where learning has a constructive, active form. The learner is actively participating in sharing ideas, searching for answers and collaborating with others. The knowledge is constructed by the learner and not just presented to the learner.

The proposed project comprises the development of an online collaborative tool called eLearningMaps, the tool will aid the process of constructing concept maps and mind maps. Also, the tool will promote collaboration by allowing multiple users to work together towards constructing such maps.

The development of eLearningMaps attempts to produce a tool that solves the challenges of knowledge representation, communication, project management and decision making by:

1. Enabling a group of people to meet in a common place by bridging geographical distance.
2. Reducing costs by minimising the need for travel.
3. Improving meeting quality by using a history feature that keeps track of changes and keeps everyone updated.
4. Enabling users to communicate in real time by developing a common workspace.
5. Improving brainstorming and sharing of ideas.

Finally, this report presents the outcomes of the research on concept mapping and mind mapping techniques, the theories behind them, how they are constructed, their uses and how they can change the way of learning.
References


Appendix A

Design idea for Ketso Mind Maps

- Represent a mind map as a tree-like structure.
- Root is in the middle, representing the central idea.
- Edges represented as tree branches.
- Tree branches can represent categories.
- Tree branches will have leaves.
- Leaves will represent ideas.
Appendix B

Draft Interface Design