UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

Use of Concept Map Scaffolds to Promote Adaptive E-Learning in Web-Based Systems

NJENGA, STEPHEN THIIRU (P58/70835/2008)

SUPERVISOR: Mr. ROBERT OBOKO

A project submitted as fulfillment for the requirements of the

degree of Masters in Computer Science

April, 2011

An educator's greatest responsibility,
is not to teach or inform,
it is to motivate and inspire.

Anonymous

Dedication

To my wife Consolata, daughter Clara and sons Dickson and Casper.

Acknowledgements

The completion of this project for the degree of Masters in Computer Science was made possible by a number of people.

My grateful thanks go to my supervisor, Mr. Robert Oboko, who gave me all the academic support that I needed for the completion of this project.

Secondly, thanks to the administration, staff and students of Kimathi University College of Technology, Nyeri for their assistance and motivation.

I would also like to sincerely thank my family for the moral, material and temporal support they accorded me during the entire period.

Finally, I owe it all to God Almighty who gave me the strength to prevail through this challenging and educative experience.

Declaration

The material presented in this research project is the original work of the candidate except as acknowledged in text. It has not been previously submitted, either in part or whole, for a degree at this or any other University.

Sign ______________ Date 6/6/2011

Stephen Thiiru Njenga

P58/70835/2008

This research has been submitted for examinations with my approval as a university supervisor.

Sign ______________ Date 9/6/2011

Mr. Robert O. Oboko

University of Nairobi

Abstract

Scaffolds are a good method of implementing self-regulated learning. Adaptive scaffolding involves having an agent, for example a human tutor who helps the learners to plan their learning, monitor their emerging understanding, use different strategies to learn, handle difficult tasks etc.

The main aim of this project is to use the adaptive scaffolds in form of concept maps in web-based e-learning systems to play the role of learner guide. The learner creates a concept map to show how he/she understands a certain domain of knowledge. The concept map takes into account the prior knowledge that the learner has in that topic, and uses it to adapt to the user level. The comparison between the concept map developed by the learner and the expert concept map is used to determine the level of understanding of the learner, which is used for the system adaptation by presenting the user with a concept map that matches his/her level. This adaptation is implemented using reference rules to incorporate intelligence.

The concept map is also used for learner evaluation to determine the final understanding of the learner in that topic. Thus, these concept map scaffolds are intended for use before, during and after learning a certain topic in order to make understanding of the topic by the learner as easy as possible.

Keywords:
Scaffold, concept maps, cognition, adaptive e-learning systems, adaptive scaffolds, learner evaluation, web-based systems, integrated assessment.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

AHS - Adaptive Hypermedia Systems

AEH - Adaptive Educational Hypermedia

AWBES - Adaptive Web-Based Education System

ITS – Intelligent Tutoring System

KBS - Knowledge Based System

RCM – Refined Concept Map

TCM – Traditional Concept Map

Chapter 1: Introduction

Cognition is the process of knowing, and includes all the mental processes that may be described as an experience of knowing (including perceiving, recognizing, conceiving, and reasoning). Easy learning takes place when the cognitive load of a learner is greatly reduced.

Cognitive maps are a good way to represent internally represented concepts and relationships among those concepts. Concepts are built from past experiences and an individual can then interpret new events/concepts from prior concepts (Weick, 1979).

A concept map is a graph in which nodes (points or vertices) represent concepts, and links (arcs or lines) represent the relationships between concepts. The concepts, and sometimes the links, are labeled on the concept map (Novak and Canas, 2008).

Scaffolding refers to a temporary structure on the outside of a building, used by workmen while building, repairing, or cleaning the building to enable them to reach *unreachable* parts of the building.

In learning, scaffolding is defined as the **assistance a teacher gives a student** in a learning situation (Montet, 2004) to reach levels not possible if the student is working alone.

The main problem of e-learning systems is not how to adapt instructions, since that has been solved by other adaptive systems, but how to develop personal preferences for e-Learning (Stoyanov, 2001). One way of achieving this is by the use of concept maps.

The choice of concept maps is driven by the fact that they are used not only as a learning tool but also as an evaluation tool as agreed by most researchers in this area (Mintzes et al., 2000; Novak, 1990; Novak & Gowin, 1984). Concept maps have been in used in various areas in learning, among them, knowledge presentation, knowledge elicitation, and more important knowledge evaluation. However, this has been done in the individual areas without any integration.

This integration, together with the incorporation of concept maps in an adaptive system is what has not been fully utilized. A good adaptive system needs to incorporate those aspects so that the maximum benefits can be realized.

1.1 Uses of concept maps

Concept maps have been in use the following areas according to Jonassen et al (1993).

1. They are used to stimulate the generation of ideas, and are believed to aid creativity. For example, concept mapping is sometimes used for brain-storming. Although they are often personalized and idiosyncratic, concept maps can be used to communicate complex ideas.
2. New knowledge creation: e.g., transforming tacit knowledge into an organizational resource, mapping team knowledge
3. Collaborative knowledge modeling and the transfer of expert knowledge
4. Increasing meaningful learning
5. Communicating complex ideas and arguments
6. Enhancing metacognition (learning to learn, and thinking about knowledge)
7. Assessing learner understanding of learning objectives, concepts, and the relationship among those concepts

Of the above uses of concept mapping, the most important ones for this project are the ones that are useful in communicating complex ideas and aiding learning by explicitly integrating new and old knowledge, as well as assessing understanding or diagnosing misunderstanding as proposed by Jonassen et al (1993).

Concept maps are known to be good in knowledge elicitation. McAleese (1998) suggested that using concept maps (nodes and relationships) to make knowledge explicit allows the learners to become aware of what they know (prior knowledge) and as a result to be able to modify what they know. This is an important factor that carries a lot of weight in this project.

The notable difference in concept maps from other cognitive mapping techniques is their emphasis on prior knowledge when learning about new concepts (Ausubel, 1968). From the work of Ausubel, Novak concluded that "Meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures" (Novak, 1993). Most of the e-learning systems do not consider the prior knowledge of the learner and thus, do not incorporate in their design and development. The use of concept maps to incorporate this prior knowledge makes them to be ranked among the best learning tools.

The individual needs of a learner are a very important consideration when developing an adaptive e-learning system. O'Donnell et. al (2002) have shown that "knowledge maps" (equivalent to concept maps in this case) can act as scaffolds to facilitate learning.

Puntambekar (2004) confirms that concept maps generated by students serve as scaffolds in form of conceptual representation of the theories and concepts that they need to solve a learning problem. He further asserts that the concept maps do allow students to see the connections between the theories that they are learning so that they get an integrated picture of the topics as opposed to studying isolated facts.

Razzaq & Heffernan(2006) did a research on the use of scaffolds in computer-based learning which showed that those students who use scaffolds ends up learning more than students who do not.

Concept maps are also used for knowledge evaluation. Assessment based on concept maps can be characterized in terms of: 1) a task that invites a learner to provide evidence bearing on his/her knowledge structure in a domain, 2) a format for the learner's response, and 3) a scoring system to evaluate learner's concept map (Ruiz-Primo & Shavelson, 1996).

1.1 Problem Statement

The main problem with the current e-learning system is that they do not some important features meant to assist the learner in the process of acquiring knowledge. Some of these features include 1) the use of prior knowledge, 2) system adaptation to match the level of the learner, and, 3) integrated knowledge assessment.

The use of prior knowledge is important in adaptive e-learning. Prior knowledge enables the learner to have a good beginning in a certain domain of knowledge and thus makes it easy to extend that knowledge.

Adaptation gives the learner a problem that matches his/her level of understanding. The learner can start with the more general problem (easy) and later to more difficult one, hence progression from one level of knowledge to another.

Knowledge assessment determines the level of understanding of the learner. This assessment enables the evaluator (teacher) to know the extent of understanding of the learner. When this assessment is integrated, it assists the learner to know immediately whether he/she is accomplishing any learning or not.

Concept maps can integrate the three features above in e-learning, and thus offer a good solution to learning problems. The proposed system prototype uses the concept maps in a web-based learning environment.

1.2 Aims and Objectives

The main goal of this project is to develop an adaptive web-based learning software prototype that uses concept maps

- to elicit the student's prior knowledge,
- to provide personalized support for learning according to the student's level of knowledge and
- for evaluating the student's level of knowledge

Chapter Summary

The proposed system prototype intends to use the concept maps in the area of e-learning. The choice of the concept maps makes it easier to incorporate the features of: 1) the use of prior knowledge, 2) system adaptation to match the level of the learner, and, 3) integrated knowledge assessment.

This prototype will enable the e-leaning to more easy and interactive.

Chapter 2: Literature Review

2.0 Introduction

This chapter gives a detailed background of scaffolding and concept maps and the many areas where concept maps have been used. It mostly explores their use in the field of e-learning. The chapter also introduces the possibility of using concept maps in adaptive e-learning systems. It specifically aims to introduce the use of prior knowledge in knowledge elicitation and evaluation using the concept maps. The possibility of use of artificial intelligence in adaptation is also explored.

2.1 Scaffolding and Learning

According to oxford dictionary, scaffolding refers to a temporary structure on the outside of a building, made of wooden planks and metal poles, used by workmen while building, repairing, or cleaning the building. It enables them to reach *unreachable* parts of the building. In learning, scaffolding is defined as the assistance (parameters, rules or suggestions) a teacher gives a student in a learning situation (Montet, 2004).

Scaffolding allows the learner to go beyond his/her ability during learning. Montet (2004) further suggests that teaching scaffolds may involve breaking a large task into smaller parts, verbalizing cognitive processes, working in peer groups, or prompting. As the student begins to work independently, the teacher removes all or some of the scaffolding.
Clay and Cazden (1992) identified two scaffolding strategies in teaching to read:

- Working with new knowledge - this occurs when a teacher suspects the child does not have the ideas or words needed for a particular text/passage, and may explain some part of the passage or contrast the presented feature with something the learner knows.

- Accepting partially correct responses - the teacher uses what is correct in the student's response but probes or cues the student, so as to suggest good possibilities for active consideration.

Some of the benefits of scaffolding in learning include more motivated learners, more time spent on learning with less on searching, and a greater chance of learners acquiring the desired skill/material.

Lewis (2007), suggested that scaffolding instruction includes a wide variety of strategies, including:

- activating prior knowledge
- offering a motivational context to pique student interest or curiosity in the subject at hand
- breaking a complex task into easier, more "doable" steps to facilitate student achievement
- showing students an example of the desired outcome before they complete the task
- modeling the thought process for students through "think aloud" talk
- offering hints or partial solutions to problems
- using verbal cues to prompt student answers
- teaching students chants or mnemonic devices to ease memorization of key facts or procedures
- facilitating student engagement and participation
- displaying a historical timeline to offer a context for learning
- using graphic organizers to offer a visual framework for assimilating new information
- teaching key vocabulary terms before reading
- guiding the students in making predictions for what they expect will occur in a story, experiment, or other course of action
- asking questions while reading to encourage deeper investigation of concepts
- suggesting possible strategies for the students to use during independent practice
- modeling an activity for the students before they are asked to complete the same or similar activity
- asking students to contribute their own experiences that relate to the subject at hand

Of the above, strategies, the use of graphic organizers and the activation of prior knowledge are very important in this research project. Lewis (2007) explains the activation of prior knowledge as the practice of beginning a lesson by bringing up topics with which the students already have some familiarity. This prior knowledge puts the upcoming lesson material into a familiar context for the students, by giving them a context into which they can then assimilate the new information and understanding.

The level of prior knowledge of the students can also be used to determine how to proceed with the lesson.

2.2 Definition of Concept Mapping

Mapping is considered as one of the few, if not single, technique that reflects the way the human mind manages information in that it mirrors the organization of thoughts. It gives a learner the opportunity to see relationships between different knowledge objects and to manipulate them in order to change the dominant thinking pattern (Stoyanov, 2001).

A concept map is a graphical technique of representing concepts and their interrelationships in a given knowledge domain. A concept map is simply a set of nodes with links joining them. The nodes are labeled and the links are simple lines often oriented and sometimes labeled.

The following diagram shows a simple concept map on nucleus.

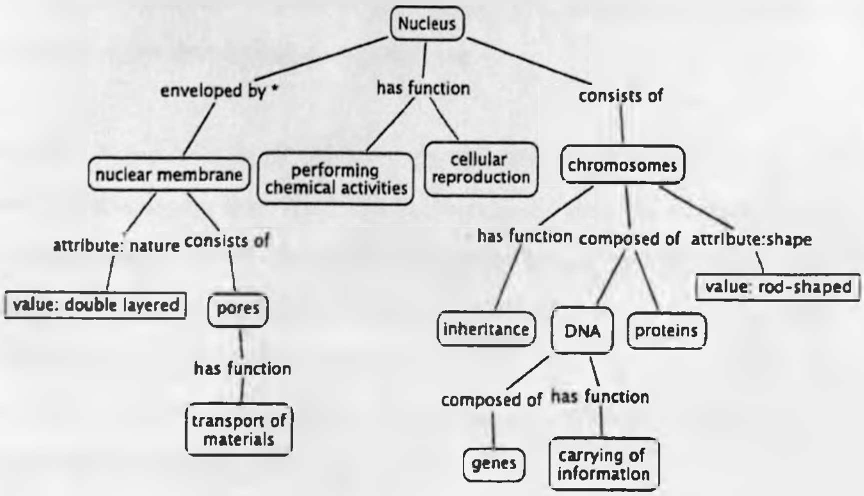

Figure 2.1: Concept map on nucleus

Kharatmal & Nagarjuna (2006) identifies two types of concept maps:

1. The traditional concept maps (TCM), where the node names and the relation names are chosen from the natural language domain of knowledge. This often leads to ambiguous concept maps.

2. Refined Concept Maps (RCM) which provides a learner with a known *finite* set of nodes and relation names. RCM representation is thought of being closer to that of subject experts.

2.3 How Concept Maps are created

Constructing a concept map begins with a domain of knowledge that is very familiar to the person constructing the map. Concept map structures are dependent on the context in which they will be used. In general, the following steps are useful in creating a concept map (Novak and Cañas, 2008):

1. The first step involves creating a concept map is to define the context by constructing a Focus Question. A Focus Question is a question that clearly specifies the problem or the issue that the concept map should help to resolve. Every concept map responds to a focus question, and a good focus question can lead to a much richer concept map. This Focus Question assists in identifying the domain and helps the learner from deviating when developing a concept map.

2. The next step is to identify the key concepts that apply to this domain. These concepts could be listed, and then from this list a rank ordered list should be established from the most general (most inclusive) concept at the top of the list, to the most specific (least general) concept at the bottom of the list. This rank order (may be approximate) helps to begin the process of map construction. This list of concepts is referred to as a parking lot, since these concepts are moved into the concept map as they are determined where they fit in.

3. The third step is to construct a preliminary concept map. This can be done by writing all of the concepts onto the appropriate locations.

4. With the preliminary map ready, the cross-links can then be established. Cross-links are links between concepts in different segments or domains of knowledge on the map that help to illustrate how these domains are related to one another. Cross-links are important in order to show that the learner understands the relationships between the sub-domains in the map. Therefore, it is necessary to be selective in identifying cross-links, and to be as precise as possible in identifying linking words that connect concepts. The figure below shows a set of concepts and a preliminary map with the cross-links in place:

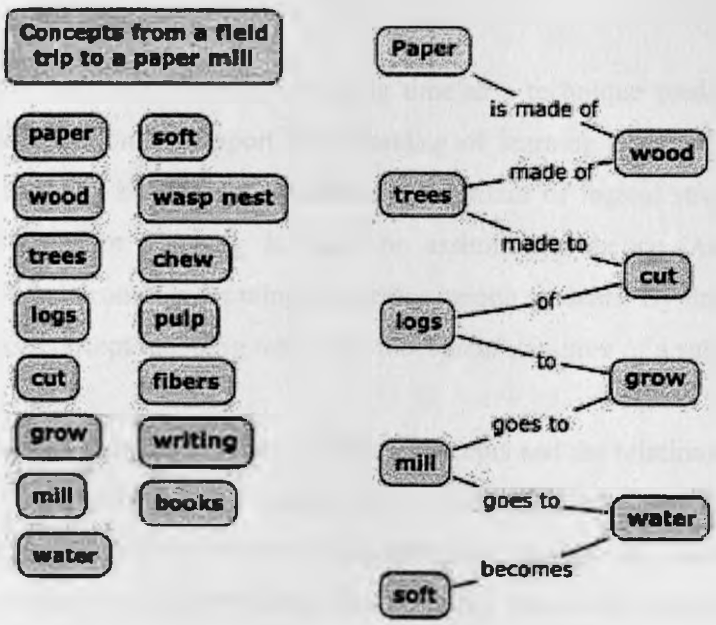

Figure 2.2: A list of identified concepts (parking lot) and concept map with some concepts

By understanding the relationship between concepts, or the meaning of the concepts, it becomes very easy for the learner to add linking words. The learners must identify the most prominent and most useful cross-links.

5. Finally, the concept map is revised; concepts re-positioned in ways that lead to clarity and better over-all structure, and a "final" map prepared.

2.4 Use of Concept Maps in Learning

Concept maps are an important learning tool, especially if adopted in a constructivist view of learning. As suggested by Bruillard & Baron (2000), a learner develops mental schema which serves to inform future thinking or action. The schemas are important to the learner in that they determine how the learner understands all experience. As indicated above, the learner begins by distinguishing one concept from another, and then uses those concepts to construct a concept map. Bruillard & Baron (2000) further argue that *effective learning* depends on the creation of new schema (concept map), or on existing schema being revised, extended or reconstructed.

Concept mapping has been viewed for a long time as a technique predominately used for knowledge representation to support understanding of learning material. Specifically, as a teaching tool, they can be used as an advanced organizer of logical structure of particular subject matter. Concept mapping is based on assimilation theory (Ausubel, Novak, & Hanesian, 1978) and promotes meaningful learning among students. By linking a set of nodes and labeled links, concept mapping represents the *logical structure* of a subject matter.

A tutor can use concept maps to identify the key concepts and the relationship between them. The structure of the to-be-learned domain can be presented before or during the learning phase, thus playing the role of advance organizer. They can also be used after the learning episode as an integrative tool (Bruillard & Baron, 2000). However, it requires using one map as the reference. The basis argument is that a learner must acquire the tutor's representation, and that the closer a learner's map is to the tutor's one, the better the result. The use of concept maps allows the learner to represent his/her current state of knowledge. The learner becomes more aware of the necessary regulation of his/her learning processes in relation to the abilities.

Learning, as a problem solving issue, is a joint undertaking between the learner and the tutor. In the area of learning, Kommers and Lanzing (1998) have defined five functions that concept mapping can support: (1) orient students, (2) articulate prior and final knowledge, (3) exchange views and ideas among students at a distance, (4) transfer learned knowledge between different topics and domains, and (5) diagnose misconceptions. Kommers (2000) has also explored the role of different mapping methods and tools in the hypermedia design process.

Concept maps can also be used to summarize what has been learnt, to teach critical thinking and problem solving skills, to self-evaluate one's comprehension and understanding, to support collaboration and cooperation, and to organize and integrate content (Alpert & Grueneberg, 2000; Novak & Cañas, 2004).

Bruillard & Baron (2000) uses a different point of view on the use of concept maps, and highlights the following uses, in relation to learning:

1. **Accessing representations** - Learning involves creating new representations and modifying existing ones. Concept maps are indeed a very useful way to gain access to the representations of learners, and to assess whether their learning is influenced by prior knowledge.

2. **Communicating** - Graphics are known to represent information in a way that sometimes may be more appropriate to communicating both contents and an idea about the complexity of content. Concept maps are not limited by linearity and are convenient to represent what can be complex and intricate. This way, they allow collaborative construction of knowledge.

3. **Co-operating** - In this context, concept maps are used in the preliminary stage that allows the bringing together of more knowledge.

Rote Learning and Meaningful Learning

Retention of information learned by rote takes place in long term memory, as does information learned meaningfully. The difference is that in rote learning, there is little or no integration of new knowledge with existing knowledge resulting in two negative consequences.

1. First knowledge learned by rote tends to be quickly forgotten, unless much rehearsed.
2. Second, the knowledge structure or cognitive structure of the learner is not enhanced or modified to clear up faulty ideas. Thus misconceptions will persist, and knowledge learned has little or no potential for use in further learning and/or problem solving (Novak, 2002).

Therefore, to structure large bodies of knowledge requires an orderly sequence of iterations between working memory and long-term memory as new knowledge is being received and processed (Anderson, 1992). The power of concept mapping in facilitating meaningful learning is that it serves as a kind of template or scaffold to help to organize knowledge and to structure it.

Basically, the goal of a concept map is to relate ideas that already exist in the students mental structures to new ideas and concepts.

2.5 Concept Maps and Hypermedia Systems

The description of a hypertext and hypermedia system, to an extent, matches the one of concept maps. A hypertext document is a simple network of nodes and links. The nodes in hypertext can be labeled by a concept name and such a structure is very similar to concept maps. Thus, it seems very natural to use concept maps in the context of hypertexts (Bruillard and Baron, 2000).

In an e-learning system, concept maps help designers in designing hypermedia or, as navigational tools, for helping learners to find an appropriate path through a lot of documents (the contents of which they do not necessarily know very precisely) (Bruillard and Baron, 2000).

The focus in the design of hypermedia systems is shifting from the transmission of knowledge to the learner to that of construction of knowledge by the learner (Bruillard and Baron, 2000). However, the structure of knowledge to be transmitted or to be acquired remains a major issue. Such a structure would provide the learner with navigational clues, in order to facilitate navigation through the materials and, possibly, the construction of new knowledge (Bruillard and Baron, 2000).

Concept maps intend to organize knowledge and to show, in a more or less explicit manner, the internal conceptual network. There is a strong consensus that concept maps facilitate hypertextual organization of knowledge, but many studies suggest that they are not as useful for learners as could be wished.

Zeiliger et al. (1997) used concept maps to allow learners to construct their own vision of the domain and facilitate the emergence of links between main concepts. They used a graphical tool for the creation of concept networks about an existing hypermedia.

2.6 Adaptive E-learning Systems and Concept maps

2.6.1 Adaptive E-learning systems

Adaptive E-learning systems are also referred to as Adaptive Hypermedia Systems (AHS) or specifically for educational purposes as Adaptive Educational Hypermedia (AEH). Brusilovsky (2002) defines an Adaptive Educational Hypermedia (AEH) system as that which deals with providing a *personalized* (individualized) educational experience, that is, one that adapts its presentation of content to the learner's needs. The adaptation, as suggested in many adaptive systems, is achieved through a user model. The user model is based on each individual user and includes features such as user goals, preferences and knowledge. This model is used in the interaction in order to adapt to the needs of that user (Brusilovsky, 1996). Of the above features, the one that is mostly used is the knowledge of the user. For the purpose of this project, this feature of knowledge is the selected option for the concept maps software prototype implementation.

The e-learners, irrespective of whether they are good in the subject matter or not, often struggle in their e-learning. The following are some difficulties that they may encounter, as noted by Stoyanov (2001):

1. **Elicitation of tacit knowledge**. The learners might not be aware of how much they know, and thus cannot express their full potential as experts.

2. **Organization of explicit expert knowledge**. This involves an effective and an efficient management of the explicit knowledge - how to use available knowledge in the best way. Facilitation is needed in the collection and analysis of information, idea generation, selection of the best solution candidate, and solution implementation.

3. **Negative individual problem solving deficiencies**. The argument here is that many people develop, for different reasons, a one-sided approach of looking at problems. Some people are good in the collection and analysis of information (seekers), some others are strong in the generation of ideas (divergers), a third group is the best in the selection of ideas (convergers), and a fourth group includes people who are confident in implementation of the ideas (practitioners).

4. **Domination of critical thinking**. People tend to be quick in arguing against other opinions, especially when discussing complex and vague information. Individuals also tend, because of different reasons, to discard some valuable ideas at the very early stage of problem solving.

Stoyanov (2001) suggests some solutions to overcome educational and training design problems. These solutions will be used in the design of the prototype for this project on adaptive e-learning system:

1. The need for operational support in structuring individual activities. This is intended to support the learner on individual capacity (adaptation).

2. The existing solutions do not deal with mental mapping and learning, and is based on modern technology in order to support non-routine and innovative use of e-learning systems. The suggested approach here is the use of concept maps to assist in mental modeling.

3. The suggested solution should consider the negative problem solving syndromes on solving e-learning problems. Facilitation of *individual knowledge management* is a way of getting the learner full potential. Such a solution should support the articulation of tacit knowledge and the effective management of explicit knowledge in

terms of the analysis of information, collection of information, idea generation, idea selection, and idea implementation. It should help in developing a flexible and versatile individual problem solving style and in establishing a striking balance between critical and creative thinking.

2.6.2 Concept Maps and Adaptive Systems

The main aim of adaptive systems is to offer *individualized* learning service to each learner. A student model needs to be developed and *updated* along the provision of appropriate material, lessons, trials and tests according to the particular goals, interests, preferences and skills of the individual (Peña and Sossa, 2004).

Ortiz et. al (2007) defines a navigable concept map as one that presents additional information when the user selects one of its elements (concepts). If the user is interested in a certain concept, the system visualizes one of more electronic documents of web pages that permit the user to learn about the concept. Basically, concept maps allow the learners to get a lot of course content with structure and coherence, in a non-linear way. They enable the learner to choose their interested concepts and then follow the strategy he/she prefers. However, a learner may be overwhelmed by a big or unknown concept map, which may show too many elements at once or provide material that the student is not prepared to understand leading to helpless and de-motivated student (Ortiz et. al, 2007). To reduce these problems, techniques from adaptive hypermedia systems can be applied so that concept maps can be adjusted to learner's features and knowledge (to only information that student is ready to comprehend).

Brusilovsky (1996) suggests that an Adaptive Hypermedia System (AHS) will conditionally show, hide, highlight or dim conditional fragments on a page when presenting it. The page may mean some other object like a link in a concept map, as used in this project. The links in the concept map are adaptively identified using different colours to indicate correctness or lack of it. Brusilovsky (1996) calls this adaptive presentation.

2.7 Concept Maps and Learner Evaluation

When concept maps are used in learning, they can also be used for evaluation. Comparing the concept map of the learner and that of the instructor ("expert" concept map) is a good way to evaluate that learner. This comparison can also be used to determine the level of the learner and be used in adaptation.

An epistemic learner model can be made from this evaluation. Later, adaptation techniques can be based on this model. Different adaptation schemes can be documented depending on the learner's errors. The challenge is proposing learner documents adapted to their prior knowledge and to difficulties they meet in learning new concepts (Delorme et. al, 2004).

2.7 Concept Maps and Artificial Intelligence

The use of concept maps has not been well incorporated in adaptive systems. The use of intelligent learning approach is one viable way to enhance adaptive systems.

Artificial Intelligence is known to offer the logistic framework and experiences in the educational area through the use of the Intelligent Tutoring Systems – ITS (Peña and Sossa, 2004). They described a conceptual proposal for the designing and management of the student model by the use of cognitive maps as a way to deal with the learning process that implies causality.

The student model, being the particular view for each user, could be built from scratch or from a general schema of concepts and fulfilled with the particular properties of the learner. Then, it can be *updated* along the assessments of the learning experiences that reveal the cognitive progress of the student.

Peña and Sossa (2004) suggest an Adaptive Web-Based Education System (AWBES) whose main goal is to provide a flexible and well-fitted education/learning service oriented to the each specific learner from a general framework. AWBES borrows the student model from

ITS. AWBES is among the few that have ventured into the use of artificial intelligence in adaptive systems.

'Knowledge representation (KR) and reasoning' is an area of artificial intelligence whose fundamental goal is to represent knowledge in a manner that facilitates inferencing (i.e. drawing conclusions) from knowledge.

2.7.1 Techniques of Representing Knowledge

There are four basic techniques for representing the acquired knowledge in a knowledge base system:

- logic
- semantic networks
- frames
- production rules

Logic

Knowledge and reasoning is represented using predicate logic or propositional logic. Propositional logic use assertions which describe things and uses logical connectives and boolean logic. This logic can reason about the world based on proven theory. However, the components cannot be individually examined. On the other hand, predicate logic extends propositional calculus by using predicates in the form function (arguments), where function is any object or relationship. Quantifiers are used to group a number of objects sharing a common characteristic. Predicate logic has well defined rules for manipulation and it is expressive. However, it cannot handle uncertainty and uses small primitives for descriptions whose numbers can be many.

Semantic Nets

Sowa (1991) defines a *semantic network* or *net* as a graphic notation for representing knowledge in patterns of interconnected nodes and arcs. This shows that a semantic network consists of a set of nodes that are connected by labeled arcs. The nodes represent concepts and the arcs represent relations between concepts. This is very similar to concept maps.

Gray (1984) also defines it as a structure used to represent associations between objects. Each object has a corresponding collection of *attributes* which are applicable to it. Some of these attributes are simple values, but others are found by following *links* in the net, which connect the object to other objects of various types.

The following diagram shows a semantic net diagram:

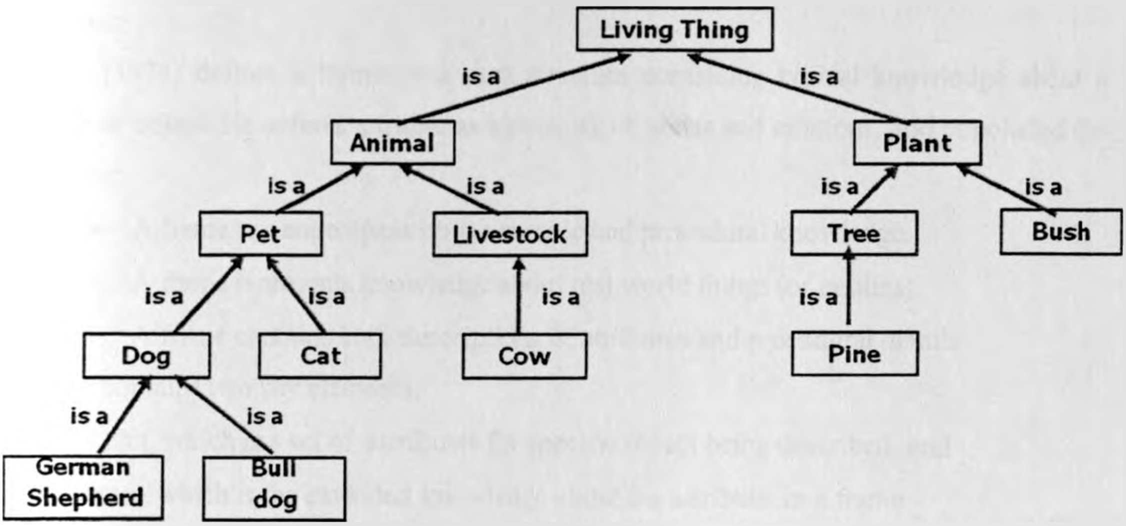

Figure 2.3: Semantic net diagram of Living Things

The idea behind a semantic network is that knowledge is often best understood as a set of concepts that are related to one another.

Sowa (1991) asserts that all semantic networks have a declarative graphic representation that can be used either to represent knowledge or to support automated systems for reasoning about knowledge.

Therefore, semantic networks can both show natural relationships between objects/concepts and be used to represent declarative/descriptive knowledge. In a semantic network inferencing involves *search and deductive* reasoning.

Semantic networks can be incomplete (no explicit operational/procedural knowledge), may lack of standards, ambiguity in node/link descriptions, and are not temporal (i.e. doesn't represent time or sequence).

Semantic networks are mainly used as an aid to analysis to visually represent parts of the problem domain. The `knowledge' can be transformed into rules or frames for implementation. The concept maps used in this research project are based on the semantic nets and the knowledge reasoning is done using the production rules.

Frames

Minsky (1974) defines a frame as a data structure containing typical knowledge about a concept or object. He defines a frame as a network of nodes and relations, and concluded the following:

- A frame can encompass both semantic and procedural knowledge.
- A frame represents knowledge about real world things (or entities).
- A frame contains both descriptions of attributes and procedural details

A frame contains two key elements;

- a slot, which is a set of attributes for specific object being described, and
- facet, which is the extended knowledge about the attribute in a frame

This knowledge in a frame may be expressed in many ways

- a simple attribute value, that can be symbolic, numeric, boolean etc
- default - the value taken if the attribute is not otherwise described
- a range - describes what type of information can appear in the attribute.
- if added - procedural knowledge i.e. what action to take when a value is added to the attribute
- if needed - procedural knowledge i.e. attribute is empty, but a value is needed

Advantages and Disadvantages of a Frame-Based Approach

Advantages

- knowledge domain can be naturally structured.
- handles both semantic/procedural knowledge.
- easy to include the idea of default values, detect missing values, include specialised procedures and to add further slots to the frames

Disadvantages

- complex
- reasoning (inferencing) is difficult

- explanation is difficult

Production Rules

Production rules use the following syntax.

IF <premise> THEN <action>

<premise> is Boolean, and is also referred to as antecedent. It can consist of a series of clauses. The AND, and to a lesser degree OR and NOT, logical connectives are also used to combine a number of <premises> or too negate.

<action> a series of statements, sometimes referred to as the consequent

A rule that contains two clauses in the antecedent connected by logical OR can be re-written as two rules

IF weather is hot OR temperature is high THEN ice-cream sales are high

could be re-written as

IF weather is hot THEN ice-cream sales are high

IF temperature is high THEN ice-cream sales are high

There are some notable differences between production rules and the conditional statements found in conventional programming languages

- Production rules are relatively independent of one another.
- Production rules can be based on heuristics or experiential reasoning.
- Production rules can accept uncertainty in the reasoning process.
- Conditional statements combine the `knowledge' and the `reasoning' in the one structure.
- Production rules simply represent the knowledge --- the inferencing or reasoning is separate.

The following is an example of a small Knowledge Based System (KBS) to help in weather prediction

R1 IF the ambient temperature is above 35 C
THEN the weather is hot

R2 IF the relative humidity is greater than 65%
THEN the atmosphere is humid

R3 IF the weather is hot AND the atmosphere is humid
THEN thunderstorms are likely (CF = 9/10)

An alternative is to write one rule (R1 & R2 are placed directly in the premise of R3). However we may wish use the statements, the weather is hot and the atmosphere is humid, for other purposes in the knowledge base.

Advantages and disadvantages of a rule-based approach

Advantages

- easy to understand the knowledge `content'.
- explanation for the reasoning is easily shown i.e. a list of which rules fired (and in which order) during reasoning.
- maintenance (or modification) is easy, provided the rule base structured well.
- uncertainty can incorporated into the knowledge base.

Disadvantages (or limitations)

- rule bases can be very large (thousands of rules)
- rules may not reflect the actual decision making
- the only structure in the KB is through the rule chaining

2.7.2 Comparative summary

The use of a particular knowledge representation varies with the suitability.

- Rules are appropriate for some types of knowledge, but do not easily map to others.
- Semantic nets can easily represent inheritance and exceptions, but are not well-suited for representing negation, disjunction, preferences, conditionals, and cause/effect relationships.
- Frames allow arbitrary functions (demons) and typed inheritance. Implementation is a bit more cumbersome.

Chapter Summary

Concept maps are good for communication, especially between the learner and the tutor, in that they combine both conceptual and graphical aspects (Bruillard & Baron, 2000). The dual coding theory confirms that if learners are presented the same conceptual material in a concept map format versus a more normal, non-graphic format, the concept mapping approach would lead to better memorization of the material (Paivio, 1991).

Stoyanov (2001) acknowledges that concept mapping has been treated mostly as knowledge representation technique. He suggests that they should not only be seen a knowledge representation technique, but also as a technique supporting knowledge elicitation, knowledge reflection, and knowledge creation.

Evaluation, being a very important activity during learning, can be done effectively using concept maps. This is done by simply comparing the learner's concept map with the teacher's concept map. This evaluation can be made simple by use of knowledge representation approaches/schemes.

Concept maps, if used for adaptation, can make use of artificial intelligence to create a user model that matches each individual user.

Chapter 3: Methodology

3.0 Introduction

This chapter discusses the research methodology of this research project. It gives details on the methods and experimental design used. It then gives the hypothesis used for data evaluation and the procedure of conducting the experiment. Finally, the chapter details how the software prototype is implemented.

3.1 Method

Several research methods were used in this research project: experimental method, prototyping and questionnaire.

3.1.1 Experimental method

This research project used a post-test only study with control group. The participants were randomly assigned to experimental and control groups. The aim of the experiment was to get data for the evaluation of the adaptive concept maps software prototype developed in order to be used in analysis.

3.1.2 Prototyping

An adaptive concept maps software prototype was developed to be used by the students in the experimental group to develop a concept map. The prototype was designed and developed during the study and is based on a selected topic (knowledge domain). It is based on *plants* topic.

Another non-adaptive concept maps software prototype was also developed for use by students in the control group.

According to DeGrace & Stahl (1990), a prototyping involves building a working model of the system, so as to obtain an early version that system. There are different types of prototypes (Hughes & Cotterell, 1996) namely throw-away prototypes, evolutionary prototypes and incremental prototypes. A throw-away prototype is used in this project because it's only used for the purpose of showing how concept maps scaffolds can be used to promote adaptive e-learning.

3.1.3 Questionnaire

A reflective questionnaire was used to investigate students' opinions/reflections about the tool they used to draw a concept map. The reflective questionnaire (Appendix 4) included items concerning the difficulties students encountered during their map constructions, the belief that concept mapping is helpful to their learning, and the affective acceptance of concept mapping as a useful learning tool. All students from the two groups were supplied with this questionnaire.

The questionnaire used a 4-point Likert scale. For each item, 1 indicated 'strongly disagree', 2 indicated 'disagree', 3 indicated 'agree', and 4 indicated 'strongly agree'. There was no provision for not agreeing or disagreeing.

3.2 General Approach

The following general approach was used in the implementation of this research project.

1. Design and implement a web-based adaptive concept maps software prototype.
2. Make a non-adaptive copy of the prototype by disabling the adaptive features of the system
3. Give the adaptive prototype to the experimental group for concept mapping. Give the non-adaptive version to the control group for use during concept mapping.
4. Determine whether the learner' using the prototype will learn better or not.

3.3 Experimental Design

The experimental approach used in this project is adopted from the work of Chang et. al (2001). The experiment was conducted on two groups; an experimental and a control group. The experimental group was used to test the effectiveness of the adaptive software prototype and the control group used the non-adaptive software prototype. Comparison was done in terms of adaptation and use of prior knowledge. Students were randomly assigned to each group. Both groups were given the same passage (Appendix 3), thus a common concept map was expected from all students.

Experimental Group

The experimental group was given the adaptive concept maps software prototype to draw the concept map. The prototype supplied both the concepts and the link labels, in addition to link annotations and learner level adaptation.

Control Group

This group constructed the concept map using a non-adaptive concept maps software prototype. This prototype also supplied the concepts and the links, but has no link annotations and user level adaptation.

3.3.1 Experimental Variables

The only independent variable in this experiment is a concept mapping tool which is in two levels: the adaptive software prototype and the non-adaptive prototype, both for drawing concept maps. There are two dependent variables: concept map production and users' reflections. This approach was adopted from the work of Stoyanov (2001).

The main objective of the experiment is studying the effect of the independent variable (software prototype) on the dependent variables (mapping production and user reflections).

3.3.2 Hypotheses

The following set of hypotheses was used in this experiment.

Hypothesis 1

This hypothesis relates the independent variable of concept map tool (which is in two levels) and the dependent variable of 'concept mapping production'. This was measured by comparing the concept map produced by the learner with the one developed by the expert. The hypothesis states as follows:

"***Students using the adaptive concept mapping tool will draw a more correct concept map than those who use the non-adaptive concept mapping tool.***"

This hypothesis has a number of sub-hypotheses which reflect the relationship between the concept mapping tools as independent variable and map production as a dependent variable. Two concept mapping tools for mapping production were used: the adaptive concept maps software prototype and the non-adaptive concept maps software prototype.

This hypothesis is described by a set of concrete assumptions, which produced the following sub-scales:

- **Correct links** – this is the total number of correct links and their correct labels used in linking the concepts used in the concept map.
- **Valid link with wrong label** – this is the number of valid links, but with the wrong labeling. A valid link is an acceptable link between any two concepts.
- **Reversed Links** – this is link that takes and end concept as the begin concept and vice versa.
- **Invalid links** – this is the number of links that are not supposed to be there for linking any two concepts. That is, those links without any meaning to the concept map.

In term of mapping production, this hypothesis was broken down into the following sub-hypotheses:

Sub-Hypothesis 1.1 – Number of Correct links

The experimental group will score better than the control group in identifying the number of 'correct links'.

Sub-Hypothesis 1.2 – Number of Valid links with wrong labels

The experimental group will score better than the control group in identifying the number of 'valid links with wrong labels'.

Sub-Hypothesis 1.3 – Number of Reversed Links

The experimental group will produce less number of 'reversed links' than the control group.

Sub-Hypothesis 1.4 – Number of Invalid Links

The experimental group will produce less number of 'invalid links' than the control group.

Hypothesis 2

This hypothesis relates the independent variable of concept mapping tool (which is in two levels) with the learning environment in terms of user attitude towards the system. In general, it evaluates the user attitudes towards the system. This was measured by using a questionnaire which was given to the subjects after developing a concept map using any appropriate tool.
The hypothesis states as follows:

"***The experimental group will be more positive and have a better attitude towards the learning environment than the control group***"

3.3.3 Experimental Subjects

Nineteen third-year Bsc. Computer Science students of Kimathi University College of Technology in Nyeri participated in the experiment. The students were randomly allocated to either experimental or control. The RAND function in excel for random number generation was used. A random number was generated and associated with each of the nineteen students. The student list was then sorted in ascending order, and the first ten (10) students were selected for the experimental group and nine for the control group.

The students in the experimental group used the adaptive concept maps software prototype to draw a concept map, and the students in the control group used the non-adaptive software prototype. Both used the same passage (domain) on plants to draw the concept map.

3.3.4 Procedure

This experiment was done using the following stages as indicated in Appendix 1 (instructions supplied to the learners):

1. The students were randomly assigned to either the control or the experimental group.
2. The students were introduced to concept maps, using an example, in order to make them familiar with the area in order to participate in the experiment. This was extracted from the literature review of this research project (see Appendix 2), which is in Chapter 2 (Literature Review).
3. The students were supplied with a paragraph (s) on the general topic of plants (see Appendix 3)
4. The students from both the control and experimental group were shortly introduced to their respective software prototypes to enable them to develop a concept map. The students from control group were introduced to the general use of the non-adaptive concept maps software development tool and the ones from the experimental group were introduced to the adaptive concept maps software development tool.
5. The students from both the control and experimental groups were asked to develop a concept map from the supplied paragraph (on plants in step 3), using the supplied concept mapping tools. Each student developed the concept map individually.
6. The students from both experimental and control groups were asked to fill in the Reflective Questionnaire (see Appendix 4).

3.4 Designing and implementing the software Prototype

3.4.1 Project Prototype

The adaptive concept maps software prototype for this project is implemented as an adaptive web-based system that is used to develop a concept. Other than being adaptive, it also offers scaffolding support to the e-learners.

There are three main concepts that are used in developing this software prototype: focus question, parking lot and expert maps.

Focus Question, Parking lot and expert skeleton maps

1. The concept maps in this project are expected to determine the level of understanding that learners have about the topic being studied.
2. By drawing the correct concept map through the required links, the students increase their understanding on the topic and the final concept maps shows the current level of understanding of that learner.
3. When drawing the concept maps, the learner is aided by link colouring to show the correctness of the drawn link. Different colours are used for correct links, valid links but wrongly labeled, reversed links and invalid links.
4. The system adapts to the level of the learner by either giving a more complex concept map to draw or a simpler one depending on the difficulty the learner faces. Thus, the concept maps can vary from level to level based on the number of the concepts to be linked; good students are supplied with all concepts to link, while poor students are supplied with fewer concepts. The number of concepts can be adjusted depending on how the student gets conversant with the topic.

There is no predetermined size of a concept map. Based on this fact, a concept map with fewer concepts is presented to a learner who is not so good in the topic. The number of concepts can be increased or decreases (by deletion the concepts) based on how the learner increases his/her understanding.

Focus Question

The starting point for constructing or filling a concept map is to understand the focus question. The quality of the resulting concept map is strongly influenced by how clear the focus question is. A good question helps learner to focus on their concept maps. (Derbentseva et al., 2004, 2006). The focus question for the above concept map is "Develop a concept map on plants".

Parking lots

A parking lot is a list of concept waiting to be added to a concept map. By supplying the concepts, the learner not only includes everything in the concept map, but also ensures that the concept map answers the focus question.

Expert Skeleton Maps

An "expert skeleton" concept map is used in this project. It is the expected and correct concept map to be compared with what the learner will develop. This comparison is used to determine the level of the learner and to guide or scaffold the learner. O'Donnell et al. (2002) have shown that "knowledge maps" can act as scaffolds to facilitate learning. The "expert skeleton" concept maps should be built by an expert on the topic.

This project which used "expert skeleton" map to scaffold learning begins with the development of a series of concept maps in a discipline, starting with the most general, most inclusive ideas and then gradually moving to more specific concept maps that will guide the learners.

The following concept map is the one used in the software prototype for this project.

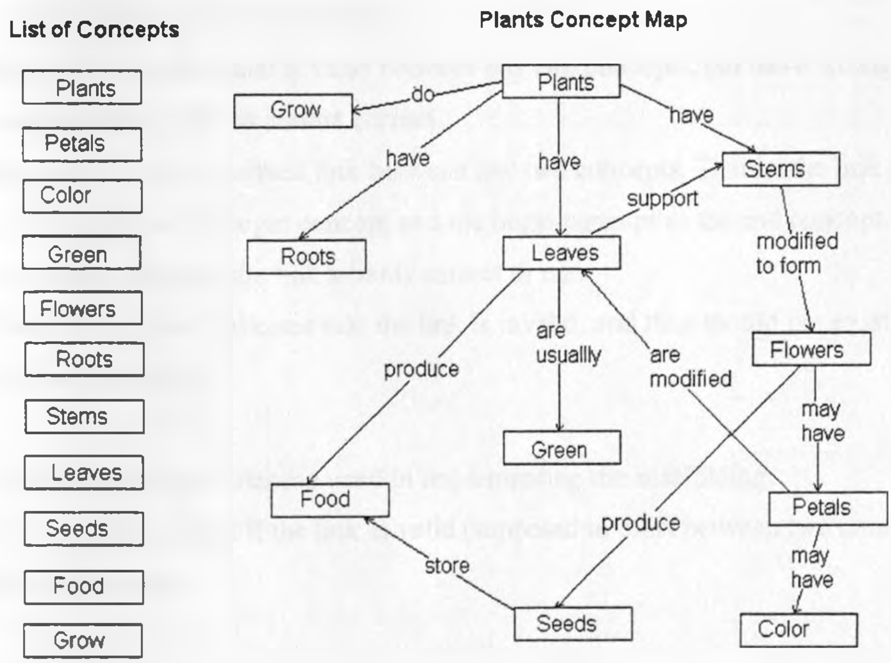

Figure 3.1: Concept map for plants.

The figure above shows a typical concept map from an educational domain on parts of a plant. As shown in the above concept map, the prototype supplies the e-learner with a set of concepts from and educational domain.

3.4.2 Scaffolding and Adaptation

Scaffolding implementation

Scaffolding in the software prototype enables the learner to reach those areas which might seem difficult or impossible. By the use of link colouring, the learner is able to get an instant feedback on whether, he/she has done the right thing in terms of drawing the correct concept. The following colouring scheme is used in the software prototype:

1. **Orange** – this colour shows that a link is valid and has the correct label. For the entire concept map to correct, all the links must be orange. Such a concept map indicates the highest level of understanding.
2. **Blue** – this is a link that is valid between any two concepts, but has a wrong label. It indicates that a link is almost correct.
3. **Magenta** – this a reversed link between any two concepts. That is, the link takes the end concept as the begin concept and the begin concept as the end concept. It does not matter whether the link label is correct or not.
4. **Red** – this colour indicates that the link is invalid, and thus should not exist between the two concepts.

The following production rules are used in implementing the scaffolding:

R1: A link is correct if the link is valid (supposed to exist between two concepts) and has correct label

R2: A link is incorrect if the link is valid but the label is wrong

R3: A link is reversed if the beginning of the link is the end and the end of the link is the beginning.

R4: A link is invalid if it is not supposed to exists between the two given concepts

R5: If a concept has no predecessor then it has no arrow going into it.

R6: If a concept has no successor then it has no arrow coming from it.

These production rules are implemented in the prototype as follows:

```
If (link is valid)
        Begin
                If(label is correct)
                        Orange colour - Correct link
                Else
                        Blue colour - Incorrect label
                End if
        Else
                If (link is reversed)
                        Magenta colour - Reversed link
                Else
                        Red colour - Invalid link
                End if
        End
```

Adaptation Implementation

The adaptation in this software prototype is achieved through the use of the number of correct and wrong relationships in the drawn concept map. The total number of correct relationships enables the learner to move to the next higher level of difficulty. The total number of wrong relationships moves the learner to the lower level (easier one). Moving to the higher level of difficultness is by adding more concepts and moving to the lower level is by removal of some concepts. The easier concept map is made of the more general concepts and the difficulty concept map is made of the more specific concepts.

The adaptation is achieved through the use of learner levels. There are three levels of adaptation:

- **Level 1** – has the least number of concepts which are more general and are found in the top part of the hierarchy.
  - This level has 5 concepts and 4 valid relationships.
  - If the learner gets 90% the relationships correct, then more concepts are added to 8 (Level 2).
  - If the total number of correct relationships is less than 50% of the total links, then the level is repeated.

- **Level 2** – is between the more general concepts and the more specific ones found at the bottom.
  - This level has 8 concepts and 7 valid relationships.
  - If the learner gets 90% of relationships correct, then the adaptation allows for 3 more concepts to be added reaching a total of 11 concepts (Level 3).
  - If the total number of correct relationships is less than 50% of the total links, then the adaptation allows for the number of concepts to be reduced to 5 (back to level 1).
- **Level 3** – this is the most difficult level and contains all the concepts that constitute this particular knowledge domain, which is considered in this project.
  - There are 11 concepts and 12 valid relationships.
  - If the learner gets 90% of relationships correct, , he/she is assumed to have understood the knowledge domain.
  - If the total number of correct relationships is less than 50% of the total links, then the learner is switched back to level 2, which has fewer concepts.

The implementation and the reasoning are done using the production rules for inferencing. For example, since 'plants' concept has no predecessor and 'roots' is a predecessor of 'plants' concept, then an arrow is not expected to be drawn from the roots to the plants. Any such arrow is wrong under all conditions. There are other production rules used. The following is a list of the production rules used:

R1: If a concept map has less than 6 concepts then it belongs to level 1.

R2: If a concept map has less than 9 but more than 5 concepts then it belongs to level 2.

R3: If a concept map has less than 12 but more than 8 concepts then it belongs to level 3

R4: If a concept map belongs to level 1 and more than 90% of the links are correct then adaptation to the next level of difficulty (level 2) occurs.

R5: If a concept map belongs to level 1 and less than 50% of the links are correct then the level is repeated.

R6: If a concept map belongs to level 2 and more than 90% of the links are correct then adaptation to the next level of difficulty (level 3) occurs.

R7: If a concept map belongs to level 2 and less than 50% of the links are correct then adaptation to the lower level of difficulty (level 1) occurs.

R8: If a concept map belongs to level 3 and more than 90% of the links are correct then learner is assumed to have understood the domain of knowledge.

R9: If a concept map belongs to level 3 and less than 50% of the links are correct then adaptation to the lower level of difficulty (level 2) occurs.

The above production rules are used sequentially.

How the concept map is stored in the system

The concept map used in the prototype is dynamically presented to the learner based on his/her level of understanding. The concept map presented can change from time to time as the learner progresses in the learning or otherwise. To facilitate this feature, the dynamic concepts and their associated links are hard-coded in the system.

3.4.3 Development Tools

The prototype was developed using the following development tools:

- Java programming language.
- Java NetBeans.

- HTML.

3.5 Data analysis approach

The statistical procedure used on the collected data is t-test for two independent (uncorrelated) and unpaired samples analysis. T-test compares the means of two samples (in this case the experimental and a control group) to determine whether there is a significant difference. The following are the reasons why t-test is the best analysis tool for this study:

- It compares two means with small sample sizes ($n \leq 30$)
- The two samples (groups) to be compared are independent from each other.
- Samples can be different sizes.
- Subjects are randomly drawn from a population.
- It involves the estimation one variable.
- Independent variable is a single variable with two levels
- The distribution of dependent variable is normal
- The standard deviation is not known and have to calculate it from the small samples

The level of significance used is 0.05. The level of significance is the probability of incorrectly rejecting the null hypothesis in a test of hypothesis and is denoted by α. Traditional values used for α are 0.05, 0.01 and 0.001.

Thus,

If $P < 0.05$ result is statistically significant, and

If $P > 0.05$ result is not statistically significant.

Chapter Summary

The chapter describes the research methodology used in the study. It gives various methods for data collection and the experimental design. It also gives the hypotheses to be used in data collection. The chapter details on how the software prototype is designed and implemented, and the artificial intelligence approaches used to enable adaptation. Lastly it identifies the data analysis tool used (t-test).

Chapter 4: Results

4.0 Introduction

This chapter presents the results from the evaluation of the Concept maps software prototype in comparison with the paper-and-pen approach. It presents the results for each of the sub-hypothesis with the main hypotheses.

4.1 Results

The statistical procedure used on the collected data is t-test distribution. T-test compares the means of two samples (in this case the experimental and a control group) to determine whether there is a significant difference.

4.1.1 Hypothesis 1

This first hypothesis states as follows:

> "***Students using the adaptive concept mapping tool will draw a more correct concept map than those who use the non-adaptive concept mapping tool.***"

This hypothesis has a number of sub-hypotheses which reflect the relationship between the concept mapping tools as independent variable and map production as a dependent variable. Two concept mapping tools for mapping production were used: the adaptive concept maps software prototype and the non-adaptive concept maps software prototype.

Sub-Hypothesis 1.1 – Number of Correct links

The experimental group will score better than the control group in identifying the number of 'correct links'.

Number of Correct Links

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	11.000000	8.000000
Variance	0.888889	2.000000
Observations	10	9
Pooled Variance	1.411765	
Hypothesized Mean Difference	0	
df	17	
t Stat	5.495213	
P(T<=t) one-tail	0.000020	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.000039	
t Critical two-tail	2.109816	

Table 4.1: t-Test analysis for 'number of Correct Links'

There was a significant difference between the two groups in terms of the number of 'correct links' - P(T<=t) two-tail = 0.000039, t Stat = 5.495213 (see Table 4.2 and Appendix 5). The students in the experimental group scored significantly higher in identifying the number of 'correct links' - P(T<=t) one-tail = 0.000020 (see Table 4.2).

Sub-Hypothesis 1.2 – Number of Valid links with wrong labels

The experimental group will score better than the control group in identifying the number of 'valid links with wrong labels'.

Number of Valid Links with wrong label

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	0.300000	1.888889
Variance	0.233333	0.611111
Observations	10	9
Pooled Variance	0.411111	
Hypothesized Mean Difference	0	
df	17	
t Stat	-5.393347	
P(T<=t) one-tail	0.000024	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.000049	
t Critical two-tail	2.109816	

Table 4.2: t-Test analysis for 'number of Valid Links with Wrong Label'

There was a significant difference between the two groups in terms of the number of 'valid links with wrong labels' - P(T<=t) two-tail = 0.000049, t Stat = -5.393347 (see Table 4.3 and Appendix 5). The students in the experimental group had a significantly higher level of 'valid links with wrong labels' than the students in the control group - P(T<=t) one-tail = 0.000024 (see Table 4.3).

Sub-Hypothesis 1.3 – Number of Reversed Links

The experimental group will produce less number of 'reversed links' than the control group.

Number of Reversed Links

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	0.200000	0.222222
Variance	0.177778	0.194444
Observations	10	9
Pooled Variance	0.185621	
Hypothesized Mean Difference	0	
df	17	
t Stat	-0.112258	
P(T<=t) one-tail	0.455967	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.911933	
t Critical two-tail	2.109816	

Table 4.3: t-Test analysis for 'number of Reversed Links'

There was no significant difference in the control group and the experimental group on 'reversed links' - P(T<=t) two-tail = 0.911933, t Stat = -0.112258 (see Table 4.4 and Appendix 5). This was expected because once the students from each group understood the chance of getting a reversed link was minimal and equally possible to either group.

Sub-Hypothesis 1.4 – Number of Invalid Links

The experimental group will produce less number of 'invalid links' than the control group.

Number of Invalid Links

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	0.000000	1.777778
Variance	0.000000	0.694444
Observations	10	9
Pooled Variance	0.326797	
Hypothesized Mean Difference	0	
df	17	
t Stat	-6.768347	
P(T<=t) one-tail	0.000002	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.000003	
t Critical two-tail	2.109816	

Table 4.4: t-Test analysis for 'number of Invalid links'

There is a significant difference on the score of the experimental group and the control in terms of 'Invalid links'- P(T<=t) two-tail = 0.000003, t Stat = -6.768347 (see Table 4.5 and Appendix 5). The control group made more irrelevant links than the experimental group because of lack of link colouring.

4.1.2 Hypothesis 2 – Learning Environment

This hypothesis relates the independent variable of concept mapping tool (which is in two levels) with the learning environment in terms of user attitude towards the system. In general, it evaluates the user attitudes towards the system. This was measured by using a questionnaire which was given to the subjects after developing a concept map using any appropriate tool.

This second hypothesis states as follows:

> ***"The experimental group will be more positive and have a better attitude towards the learning environment than the control group"***

Learning Environment

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	33.400000	25.777778
Variance	4.711111	7.694444
Observations	10	9
Pooled Variance	6.115033	
Hypothesized Mean Difference	0	
df	17	
t Stat	6.708519	
P(T<=t) one-tail	0.000002	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.000004	
t Critical two-tail	2.109816	

Table 4.5: t-Test analysis for 'learning environment'

There is a significant difference on the 'learning environment' between the experimental group and the control group - P(T<=t) two-tail = 0.000004, t Stat = 6.708519 (see Table 4.6 and Appendix 5). The experimental group got more of this support - P(T<=t) one-tail = 0.000002 (see Table 4.6)

Chapter Summary

The chapter presented the results of the analyses of data collected. The data was analyzed using t-test to show if there was a difference in means on the two groups (the experimental group and the control group).

As for the first hypothesis, the results showed that there is a significant difference in some areas and not in others. Basically the significant differences were identified in the areas of 'correct links', 'valid links with wrong labels', 'invalid links'. However there was no significant difference in the areas of 'reversed links'.

In the second hypothesis, the learning environment used by the experimental group was more superior than the one used by the control group. The experimental group had a better attitude than the control group.

Chapter 5: Discussion and Conclusion

5.0 Introduction

The main aim of this experiment was to show that concept maps scaffolds can be used to facilitate adaptive learning. This is in terms of not only knowledge elicitation and presentation, but also in terms of knowledge evaluation. The experiment provided data to assist in answering the question of whether concept maps scaffolds can offer adaptive support to learners in understanding a certain domain. However, some assumptions and limitations could have affected the results.

5.1 Assumptions and Limitations

The results derived in this research project may have been affected by some assumptions and limitations. They include:

- The students who participated in the experiment belonged to only one learning institution (Kimathi University College of Technology).
- The students only belonged to one group within the university college (Third Year, Bsc. Computer Science).

5.2 Discussion

The result of the analyses of the collected data showed that the experimental group (the one using the adaptive software prototype) scored significantly higher than the control group (the one using non-adaptive software prototype) in all the sub-variables except one (number of reversed links).

The first hypothesis dealt with the relationship between the concept mapping tool (independent variable) and the concept map produced (dependent variable). It had four sub-hypotheses on 'correct links', 'valid links with wrong labels', 'reversed links' and 'invalid links'.

The experimental group was better in identifying the 'correct links' than the control group. This was largely due to the scaffolding support provided by the adaptive software prototype. A learner in the experimental group could know immediately after drawing a link whether it was correct or not. This meant that the learner could make corrections immediately. This was not possible in the control group.

There was no significant difference in the number of 'reversed links' (P(T<=t) two-tail = 0.911933). This is due to the fact that if a learner does not understand the domain, it does not matter what tool he/she is using to develop the concept map. Thus, the problem was identified equally in both groups.

The control group produced a significantly higher number of 'Invalid links' than the experimental group (P(T<=t) two-tail = 0.000003). The experimental group was in a position to know any invalid link immediately due to the link colouring offered by the adaptive system when drawing the concept map.

The experimental group was more positive and better attitude on the learning environment than the control group (P(T<=t) two-tail = 0.000004). This learning environment tested, using a questionnaire, the level of scaffolding support, adaptive support and use of prior knowledge.

The experimental group using the adaptive concept maps software got more scaffolding support than the control group using the non-adaptive one. (Appendix 4 and appendix 5).

The adaptive support offered to the experimental group was also significantly high. This adaptation was in form of regulating the levels of difficulty depending on the understanding of the learner.

The use of prior knowledge is significantly prominent in the experimental group than control group. By moving from a lower level of difficulty to a higher one, the learner in the experimental group makes use of the prior knowledge used in that lower level to develop a more complex concept map in the higher level. This was not possible for the control group.

5.3 Conclusions

The adaptive concept maps software prototype purposed to introduce the concept maps in e-learning web systems. This adaptation was introduced in form of regulating the levels of difficultness of the concept map based on the user understanding. Also, scaffolding is used through link annotations to enable the learner to reach greater height.

The control group was not supplied with the scaffolding and the adaptation features.

This research project provided additional insight into the adaptive use of concept maps in web-based e-learning. The research found that the concept maps scaffolds can be used adaptively in e-learning. The main aim of the experimental validation of the software prototype was to get some quantitative data about the adaptive use of concept maps in web-based e-learning.

Generally, it can be concluded that the software prototype could be an effective tool for adaptive e-learning since:

- It enables the learners to easily reach those areas in a given topic that may seem unreachable (scaffolding).

- It incorporates individualized learning by adaptively presenting the learner with a concept map that matches his/her level of understanding. As the learner improves on the understanding, more concepts are added and as the learner performs poorly the concepts are reduced.

- It enables the use of prior knowledge where the learner can use what he knew from the previous level if he/she moves to the next level of difficulty.

- It evaluates the level of the learner by enabling the learner to do some self-evaluation when drawing the concept map. This is through an evaluation facility to check the correctness of the drawn concept map.

In this research project, we conclude that we have demonstrated the feasibility of the concept maps as an adaptive e-learning tool, not just for knowledge elicitation and representation, but also for knowledge evaluation. The use of concept maps for adaptive e-learning is a good and viable option for enhancing adaptive e-learning. The four main features of scaffolding, adaptation, prior knowledge and evaluation have not been used in an integrated form effectively in the existing adaptive e-learning systems. This has been achieved in this research project. The use of production rules has made it possible for adaptation implementation.

Reference:

Alpert, S.R. & Grueneberg, K. (2000). Concept Mapping with Multimedia on the Web. Journal of Educational Multimedia and Hypermedia.

Ausubel, D.P. (1968). Educational Psychology: A Cognitive View. New York: Holt, Rinehart & Winston.

Ausubel, D,P., Novak, J.D., & Hanesian, H. (1978*). Educational psychology. A cognitive view*. New York: Holt, Rinehart and Winston.

Bruillard, E. and Baron, G. (2000).*Computer-based concept mapping: a review of a cognitive tool for students*.

Brusilovsky, P. (1996). Methods and techniques of adaptive hypermedia. *User Modeling and User-Adapted Interaction.*

Brusilovsky, P. (2002). *Adaptive hypermedia, User Modeling and User Adapted Interaction*, Ten Year Anniversary Issue (Alfred Kobsa, ed.).

Chang, K.E, Sung, Y.T & Chen S.F(2001). *Learning through computer-based concept mapping with scaffolding aid.* National Taiwan Normal University, Taipei, Taiwan.

Clay, M., & Cazden, C. (1992). A Vygotskian interpretation of reading recovery. In L.C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of socio-historical psychology*. New York: Cambridge University Press.

Cotterell, M., & Hughes, B. (1996). *Software project management*. London: International Thomson Computer Press.

DeGrace, P., & Stahl, L. (1990*). Wicked problems, righteous solutions: A catalogue of modern software engineering paradigms*. Englewood Cliffs, New Jersey: Prentice Hall.

Delorme, F., Delestre, N. and Pecuchet J. (2004). Using Concpet Maps for enhancing Adaptation Processes in Declarative knowledge learning. Laboratiore PSI – INSA de Rouen.

Derbentseva, N., Safayeni, F., & Cañas, A. J. (2004). Experiments on the effects of map structure and concept quantification during concept map construction. In A. J. Cañas, J. D. Novak, J.D. & Gonzâlez, F.M. (Eds.). *Concept Maps: Theory, Methodology, Technology. Proceedings of the First International Conference on Concept Mapping.* Pamplona, Spain: Universidad Pública de Navarra.

Derbentseva, N., Safayeni, F., & Cañas, A. J. (2006). Two strategies for encouraging functional relationships in concept maps. In A. J. Cañas & J. D. Novak (Eds.) *Concept Maps: Theory, Methodology, Technology. Proceedings of the Second International Conference on Concept Mapping.* San José, Costa Rica: Universidad de Costa Rica.

Gray, P. M. D. (1984). Logic, Algebra and Databases. Ellis Horwood Limited.

Jonassen, D., Beissner. K., & Yacci, M. (1993). *Structural knowledge*. New Jersey: LEA.

Kommers, P. (2000). Four stages in designing educational hypermedia. *International Journal of Continuing Engineering Education and Life-Long Learning.*

Kommers, P., & Lanzing, J. (1998). Students' concept mapping for hypermedia design: Navigation through world wide web (www) space and self-assessment. *Journal of Interactive Learning Research.*

Lewis, B. (2007). Scaffolding Instruction Strategies. *Techniques to Scaffold Learning in the Elementary Classroom.* http://k6educators.about.com/od/helpfornewteachers/a/scaffoldingtech.htm (accessed 4th April 2010)

McAleese, R. (1998). A theoretical view on concept mapping.

Minsky, M. (1974). A Framework for Representing Knowledge. MIT-AI Laboratory Memo 306.

Mintzes, J. J., Wandersee, J. H., & Novak, J. D. (2000). *Assessing science understanding: A human constructivist view*. San Diego: Academic Press.

Montet, M. (2004). What Is Scaffolding in Teaching? http://www.ehow.com/facts_5162695_scaffolding-teaching.html#ixzz1E1dq4jU9 (accessed 4th April 2010)

Novak, J. D. (1990). Concept maps and vee diagrams: Two metacognitive tools for science and mathematics education.

Novak, J. D. (1993). Human constructivism: A unification of psychological and epistemological phenomena in meaning making. *International Journal of Personal Construct Psychology.*

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or appropriate propositional hierarchies (liphs) leading to empowerment of learners.

Novak, J.D. & Cañas, A.J. (2004). *Building on New Constructivist Ideas and the CmapTools to Create New Model for Education.* First International Conference on Concept Mapping: Theory, Methodology, Technology. Pamplona, Spain. Universidad Pública de Navarra.

Novak J.D. & Cañas A.J.(2008). The Theory Underlying Concept Maps and How to Construct and Use Them. Florida Institute for Human and Machine Cognition, Pensacola Fl, 32502.

Novak, J.D., & Gowin, D. (1984). *Learning how to learn.* Cambridge: Cambridge University Press.

O'Donnell, A.M., Dansereau, D.F., & Hall, R.H. (2002). Knowledge maps as scaffolds for cognitive processing. *Educational Psychology Review.*

Ortiz, F.O., Medina, N. M., Cabrera L.G. (2007). *Applying a Semantic Hypermedia Model to Adaptive concept maps in education.*

Paivio, A. (1991) Dual Coding Theory: retrospect and current status. *Canadian Journal of Psychology.*

Peña, A. & Sossa, H. (2004). *Using Cognitive Maps to Develop a Student Model (2004), México, D.F., MEXICO.*

Puntambekar, S (2004). *An integrated approach to individual and collaborative learning in a web-based learning environment.* University of Connecticut.

Razzaq L. & Heffernan, N.T.(2006). Towards designing a user-adaptive web-based e-learning system. Computer Science Department Worcester Polytechnic Institute Worcester, MA.

Ruiz-Primo M.A, & Shavelson R.J.(1996). *Problems and issues in the use of concept maps in science assessment*. Journal of Research in Science Teaching.

Sowa, J.F. (1991). Principles of Semantic Networks: Explorations in the Representation of Knowledge. Elsevier Science & Technology Books.

Stoyanov S. (2001), *Mapping and in the Educational and Training Design*, Thesis University of Twente, Enschede, Print Partners IpsKamp, Enshede.

Weick, K.E (1979). *The Social Psychology of Organizing Reading* MA:Addison & Wesley.

Zeiliger, R., Reggers, T., Balewyns, L. and Jans, V. (1997). *Facilitating web navigation: Integrated tools for active and cooperative learners.* 5th International Conference on Computers in Education, Kuching, Sarawk, Malaysia.

Appendices

Appendix 1: Instructions to students

Dear all,

This project is about the use of concept maps scaffolds in promoting adaptive e-learning systems. Its aim is to find out whether the concept maps can be used not just as scaffolds, but also to regulate the level of learning of the individual student.

You will take part in evaluating the project prototype. You will either be using an adaptive concept maps software prototype or a non-adaptive one for drawing a concept map. The two approaches are important in this evaluation.

The following are the tasks/steps that you will undertake in this evaluation. The estimated times you should spend on each task.

1. You will be provided with an introduction to the concept maps that will give you some awareness in this field and an example on a concept map. (15 minutes).
2. Next you will be provided with a general passage about plants. You are supposed to read and understand this passage before moving to task number 3. (15 minutes).
3. Thirdly, you will draw a concept map from the passage in (2). You will do it using either the adaptive software prototype or the non-adaptive one. (30 minutes).
4. Lastly, you will be provided with a reflective questionnaire which you will use to indicate the extent to which you agree with the supplied questions. This is your evaluation part of the concept maps. (Between 5 and 10 minutes).

The time indicated on each task is the maximum for that task. However, if you complete a task before the allocated time, you may move to the next task.

Your willingness to take part in this research project will be highly appreciated.

Yours Sincerely,

Njenga S.T.

Appendix 2: Introduction to concept maps

Instructions: Use a maximum of 15 minutes to read this introduction.

A concept map is a graphical technique of representing concepts and their interrelationships in a given knowledge domain. A concept map is simply a set of nodes with links joining them. The nodes are labeled and the links are simple lines often oriented and named.

The following diagram shows a simple concept map on

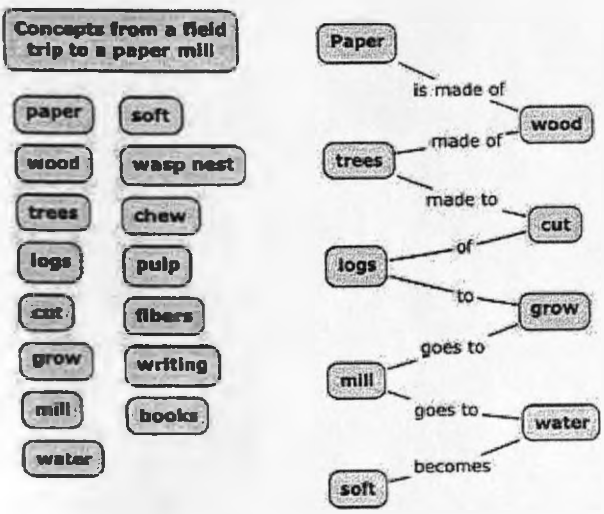

Figure 1: A list of identified concepts in the parking lot on the left and a concept map with some of the concepts on the right

To develop a concept map, you would generally do the following.

1. Identify the key concepts that apply to this domain. These concepts could be listed, and preferably ranked from the most general (most inclusive) concept at the top of the list, to the most specific (least general) concept at the bottom of the list. This rank order (may be approximate) helps to begin the process of map construction. This list of concepts is referred to as a parking lot. In the figure above, the parking lot is the left.
2. Next, construct a preliminary concept map. This can be done by writing all of the concepts onto some selected/appropriate locations.
3. Cross-links can then be established. These are links between concepts that help to illustrate how these concepts are related to one another. It is necessary to be selective

in identifying these links, and to be as precise as possible in identifying linking words that connect concepts.

4. Finally, the concept map is revised; concepts re-positioned in ways that lead to clarity and better over-all structure, and a "final" concept map prepared.

The final concept map shows the extent to which the learner understands the topic/subject. The more accurate the concept map, the more the learner will have understood.

Appendix 3: Passage on Plants

Read the passage below and understand it, since you will use it to draw a concept map. (maximum 15 minutes)

INTRODUCTION TO PLANTS

Plants are derived from the larger class of living things. A plant, just like any other living thing, grows for it to mature. A plant is made up of the following important components: roots, stems and leaves.

The leaves are normally important in that they produce food, mostly, to animals. Leaves are usually green in colour. Leaves are also important to the plants in that they support stems. Stems are modified to form flowers.

Flowers are the ones that produce seeds. Flowers may also have petals. The seeds produced by flowers are known to store food. The petals are nothing else but modified leaves. These petals may have color.

Required:

Draw a concept map using either the software prototype or a paper-and-pen. You will be supplied with either, for this task.

Once you are through with your drawing, alert the in-charge, so that you can start the next task.

Appendix 4: Reflective Questionnaire

(maximum 10 minutes)

This questionnaire is aimed at getting a feedback from you on the use of concept maps software in learning, and especially in your understanding on the given passage.
Please answer each of the questions by indicating the extent to which you agree or not agree with it. For each item, 1 indicates 'strongly disagree', 2 indicates 'disagree', 3 indicates 'agree', and 4 indicates 'strongly agree'. There is no right or wrong answer. Filling in the questionnaire should be done after you have drawn a concept map on plants using the supplied software prototype. The accuracy of the results depends on how honest you can be.

Thank you.

Please indicate what you used in order to draw the concept map.

☐ Software Prototype with scaffolds and adaptation

☐ Software Prototype without scaffolds and adaptation

Key:

1 - strongly disagree

2 – disagree

3 – agree

4 - strongly agree

1. I was able to know when making mistakes, and subsequently was able to make corrections in the process of drawing the concept map.

   ☐4 ☐3 ☐2 ☐1

2. The system immediately informed me when I made a mistake with every addition of either concept or link to my concept map.

   ☐4 ☐3 ☐2 ☐1

3. I was able to use the systems feedback to know whether I made mistakes or not while still drawing the concept map.

   ☐4 ☐3 ☐2 ☐1

4. The system guided me from an easy approach to a difficult one as I advanced in my construction of a concept map.

4	3	2	1

5. The system enabled me to draw a reasonably correct concept map which I never expected to achieve.

4	3	2	1

6. The system noted my level of understanding and could regulate itself based on the level of difficultness.

4	3	2	1

7. The system could tell me at what level I was working in when drawing my concept map.

4	3	2	1

8. I felt that I could extend the concept map if supplied with more concepts.

4	3	2	1

9. The system allowed me to extend a concept map with ease by supplying more concepts and relationships.

4	3	2	1

10. I was able to use previous knowledge from one level to another to extend my concept map.

4	3	2	1

Name (optional)..

Appendix 5: Raw Data

		Concept Map Production				
S/No	Group	Correct links	Valid link, wrong label	Reversed Links	Invalid Links	Learning Environment
1	1	12	0	0	0	36
2	1	11	0	0	0	35
3	1	12	0	0	0	32
4	1	10	1	0	0	35
5	1	12	0	0	0	31
6	1	12	0	0	0	35
7	1	10	1	1	0	33
8	1	10	1	0	0	34
9	1	10	0	0	0	29
10	1	11	0	1	0	34
11	2	9	1	0	2	26
12	2	10	1	0	2	27
13	2	7	2	1	3	26
14	2	6	3	0	2	25
15	2	8	2	0	2	29
16	2	6	2	1	0	19
17	2	9	1	0	2	27
18	2	8	3	0	1	27
19	2	9	2	0	2	26

Appendix 6: t-Test Analysis for Raw Data

No. of Links

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	11.500000	12.333333
Variance	0.500000	1.500000
Observations	10	9
Pooled Variance	0.970588	
Hypothesized Mean Difference	0	
df	17	
t Stat	-1.840966	
P(T<=t) one-tail	0.041574	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.083147	
t Critical two-tail	2.109816	

Correct Links

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	11.000000	8.000000
Variance	0.888889	2.000000
Observations	10	9
Pooled Variance	1.411765	
Hypothesized Mean Difference	0	
df	17	
t Stat	5.495213	
P(T<=t) one-tail	0.000020	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.000039	

t Critical two-tail	2.109816

Valid Links Wrong label

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	0.300000	1.888889
Variance	0.233333	0.611111
Observations	10	9
Pooled Variance	0.411111	
Hypothesized Mean Difference	0	
df	17	
t Stat	-5.393347	
P(T<=t) one-tail	0.000024	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.000049	
t Critical two-tail	2.109816	

Reversed Links

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	0.200000	0.222222
Variance	0.177778	0.194444
Observations	10	9
Pooled Variance	0.185621	
Hypothesized Mean Difference	0	
df	17	
t Stat	-0.112258	
P(T<=t) one-tail	0.455967	
t Critical one-tail	1.739607	

P(T<=t) two-tail	0.911933
t Critical two-tail	2.109816

Invalid Links

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	0.000000	1.777778
Variance	0.000000	0.694444
Observations	10	9
Pooled Variance	0.326797	
Hypothesized Mean Difference	0	
df	17	
t Stat	-6.768347	
P(T<=t) one-tail	0.000002	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.000003	
t Critical two-tail	2.109816	

Learning Environment

t-Test: Two-Sample Assuming Equal Variances

	Adaptive	*Non Adaptive*
Mean	33.400000	25.777778
Variance	4.711111	7.694444
Observations	10	9
Pooled Variance	6.115033	
Hypothesized Mean Difference	0	
df	17	
t Stat	6.708519	
P(T<=t) one-tail	0.000002	

t Critical one-tail	1.739607
P(T<=t) two-tail	0.000004
t Critical two-tail	2.109816

Key:

Hypothesized Mean Difference – set at zero to show there is no difference in population means. This assists in determining the probability of obtaining the given results by chance.

df: Degrees of freedom

t-Stat - This shows the t value calculated from the data.

P(T<=t) one-tail - used if we wish to test only that one particular mean is larger (or smaller) than the other.

P(T<=t) two-tail - This shows the probability of getting our calculated t value by chance alone. That probability is extremely low, so the means are significantly different.

t Critical two-tail - This shows the t value that we would need to exceed in order for the difference between the means to be significant at the 5% level.