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

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ABSTRACT
Scaffolds are a good method of implementing self-regulated learning. Use of prior knowledge makes the learner to understand a topic better. Learner adaptation enables a learner to be presented with content that matches his/her level of understanding.
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 from prior knowledge to show how he/she understands a certain domain of knowledge. The concept map takes into account the knowledge of the learner in that topic, and uses it to adapt to the user level. This is done by integrated evaluation where the learner is presented with a concept map that matches his level of understanding as he/she draws the concept map. The scaffolding and the adaptation are implemented using production rules.

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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).

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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.

2. SOME USES OF CONCEPT MAPS IN LEARNING

Effective learning depends on the creation of new schema (concept map), or on existing schema being revised, extended or reconstructed. Concept maps are used in many ways in learning. Among those uses, the ones used in this project include:

1. They make knowledge explicit, thus allow the learners to become aware of what they know (prior knowledge) and as a result be able to modify what they know to create new knowledge.
2. They are used as scaffolds – they enable a learner to reach unreachable areas thorough step by step guidance. Teaching scaffolds may involve breaking a large task into smaller parts. The learner is guided from an easy to a more difficult task.
3. Knowledge evaluation – This is assessment by comparing the concept map drawn by the learner and the expert concept map.

The use of prior knowledge is important in learning. The learner is able to use prior knowledge to build onto new knowledge.

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). Guiding the learner from one level of knowledge to another (learning) enables the learner to learn with ease. The learner can start with the more general things (easy) and later move to more specific ones (more difficult), hence progression from one level of knowledge to another (Raleigh, 1997). This approach is naturally achieved implemented using hypermedia as is the case with web-based learning (Hoffman, 1997).

Knowledge assessment can determine the level of understanding of the learner by comparing what the learner knew before learning and what he/she knows after learning. A web-based concept map learning system proposed in this project provides and facilitates the use of the above features to promote learning.

2.1 Use of Concept Maps to realize Adaptation in Web-based Learning

The notable difference in concept maps from other cognitive mapping techniques is their emphasis on prior knowledge when learning about new concepts (Ausubel 1968). This prior knowledge is used as the starting point in drawing a concept map, and later extend the concept map by adding more concepts, thus learning taking place.

The main aim of adaptive systems is to offer *individualized* learning service to each learner (Peña and Sossa 2004). Adaptive Educational Hypermedia (AEH) deals with providing a personalized educational experience by adapting its presentation of content to the learner's needs. An Adaptive Hypermedia System (AHS) may conditionally show, hide, highlight or dim conditional fragments of the system (Brusilovsky 1996).

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 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).

In this study, adaptation was offered by regulating the number of concepts and concept links provided to the learner. The adaptation was guided by the learner's level of knowledge. The level of knowledge was estimated according to the number of correct concepts and relationships between concepts in a concept map presented by a student. This adaptation was implemented using production rules.

2.2 Concept Maps and Learner Evaluation

Comparing the concept map of the learner and that of the instructor ("expert" concept map) was used to evaluate the learner. This comparison was also used to determine the level of the learner and thus important in implementing adaptation. A learner model was made from this evaluation, prompting for the particular adaptation schemes mentioned above.

2.3 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.

3. AIMS AND OBJECTIVES OF THIS STUDY

To develop an adaptive web-based learning software prototype that uses concept maps

- To make use of 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

4. HYPOTHESES

This study used two hypotheses

Hypothesis 1

"*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 was further split into four 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
“*The experimental group will be more positive and have a better attitude towards the learning environment than the control group*”

5. USE OF CONCEPT MAPS TO REALIZE ADAPTATION IN WEB-BASED LEARNING
Adaptive Educational Hypermedia (AEH) deals with providing a personalized educational experience by adapting its presentation of content according to the learner's needs. Mostly, adaptation 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.

An Adaptive Hypermedia System (AHS) will conditionally show, hide, highlight or dim conditional fragments of the system (Brusilovsky 1996). In this study, adaptation is achieved by hiding some concepts and relationships from the student. A student model needs to be constantly updated to reflect the current status of the student, which is used to guide adaptation

The learner’s level of knowledge in the learner model was used to guide adaptation of concept maps. The level of knowledge was estimated according to the number of correct concepts and relationships between concepts in a concept map presented by a student, using a rule-based approach. The number of concepts and number of concept links made available to the student were adapted according to the learner’s level of knowledge.

6. METHODOLOGY
The following general approach was used:

1. Designing and implementing a web-based adaptive concept maps software prototype.
2. Making a non-adaptive copy of the prototype by disabling the adaptive features of the system
3. Giving the adaptive prototype to the experimental group for concept mapping. Giving the non-adaptive version to the control group for use during concept mapping.
4. Determining whether the learner’ using the prototype will learn better or not.

6.1 Experimental Design
An experiment was conducted on two groups; an experimental and a control group. Students were randomly assigned to each group. Both groups were given the same passage (domain) on plants and used it to draw a concept map.

Experimental Group
The experimental group was given the adaptive concept maps software prototype to draw the concept map.

Control Group
This group constructed the concept map using a non-adaptive concept maps software prototype.

Both prototypes provided the students with possible concepts and links (relationships) from that particular domain.

6.2 Experimental variables
There was one independent variable in this experiment (a two-level concept map tool: the adaptive software prototype and the non-adaptive prototype, both for drawing concept maps). There are two dependent variables: concept map production and learning environment.

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

6.3 Experimental Subjects

Nineteen (19) third-year BSc. Computer Science students of KUCT participated. The students were randomly allocated to either the experimental or control group. Both used the same passage (domain) to draw the concept map.

6.4 Experimental Procedure

The following procedure was used in conducting the experiment:

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.
3. The students were supplied with a passage on the general topic of plants.
4. The students from both groups were shortly introduced to their respective software prototypes to enable them to develop a concept map without any technical problems.
5. The students were asked to develop a concept map from the supplied paragraph (on plants in step 3), using the supplied web-based concept mapping tools. Each student developed the concept map individually.
6. The students were constantly assessed (ongoing work) on the concept map construction.
7. The students were evaluated based on the concept map produced to determine the final level of understanding on the topic.
8. The students from both experimental and control groups were asked to fill in the questionnaire to assess the learning environment**.**

7. DESIGNING AND IMPLEMENTING CONCEPT MAPPING TOOL

The concept mapping prototype was for a particular topic (plants in general). A list of concepts (parking lot) was supplied. By supplying all the concepts in the domain, the system assures that the learner not only includes all the concepts in the concept map, but also ensures that the concept map answers the focus question. An expert map, which is the expected and correct concept map, was used for comparing with what the learner will develop. This comparison is used for adaptation and learner guidance (scaffolding).

Scaffolding in the software prototype enabled the learner to reach those areas which might seem difficult or impossible. By the use of link annotation (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:

- **Orange** – This colour shows that a link is valid and has the correct label. For the entire concept map to be correct, all the links must be orange. Such a concept map indicates the highest level of understanding.
- **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.
- **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.
- **Red** – This colour indicates that the link is invalid, and thus should not exist between the two concepts.

Adaptation in this software prototype is achieved through the use of the number of correct relationships in the drawn concept map. There are three levels of knowledge of the learner used in this study: beginner, intermediate and expert. There were also three multi-representations of the domain, to match the three levels of knowledge of the learner: level 1, level 2 and level 3. A higher level of difficulty has more concepts and a lower level has fewer concepts. The easier concept map is made of the more general concepts and the difficulty concept map is made of the more specific concepts. Adaptation is realized through adding or removing concepts and their links from the parking lot, depending on the learner's current level of knowledge. Level of knowledge is estimated from the number of correct relationships. The total number of correct relationships enables the learner to move from the current level to the next higher level of concept difficulty or to the lower one (easier one).

8. RESULTS OF THE EXPERIMENT

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 between the two groups

Hypothesis 1.1 – Number of Correct Links

The experimental group will score better than the control group in identifying the 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 (Table 1.1)

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 1.1: t-Test analysis for 'number of Correct Links'

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'
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(Table 1.2)

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

Table1.2: t-Test analysis for 'number of Valid Links with Wrong Label'

9. DISCUSSION

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 experimental group was better in identifying the number of 'correct links' than the control group (P(T<=t) two-tail = 0.000039). This was 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 due to link colouring. The learner in the control group was not aware when the link was correct or not. This matched the hypothesis.

Experimental group had a significantly higher number of 'valid links, but wrong label' than the control group (P(T<=t) two-tail = 0.000049). The scaffolding facility (link annotation) offered by the adaptive system guided the learner as opposed to the non-adaptive system. This again matched the hypothesis.

10. CONCLUSION

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.

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 personalized 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 while drawing the concept map. Evaluation is also done at the end of drawing the concept map, to check the final understanding of the learner in that area.

11. FURTHER WORK

In order to test the reliability of the concept maps in adaptation support, experiments should be carried out using a bigger sample than has been used in this study, which has 19 participants only. This will increase their reliability in this area of adaptation.

Furthermore, many areas of study need to be tested and with different classes of participants. Only one area of plants was used in this study and with a particular group of students from computer science. This will make the approach more acceptable to the other areas of learning.

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