CONCEPT MAPPING IN LECTURES

Janet Lavery
Active Learning in Computing
Department of Computer Science
University of Durham
janet.lavery@durham.ac.uk
www.dur.ac.uk/alic/

Adam Low
Active Learning in Computing
Department of Computer Science
University of Durham
a.c.low@durham.ac.uk
www.dur.ac.uk/alic/

ABSTRACT

Concept maps are an aid to a deep learning strategy. Developing concept maps would help students understand the relationships between concepts both within a domain and across related domains. To encourage students to explore the use of concept maps, we have integrated concept maps into a module's lectures. We have trialled: a concept map developed by experts and given to students; another concept map developed collaboratively by the students in an interactive lecture supported by a free-text response system; and finally a concept map developed incrementally in a series of lectures.

Keywords

Concept maps, Free-text response, Interactive lectures

1. BACKGROUND

The Computer Systems level-one module is concerned with the historical, technical, and social issues surrounding complex distributed computer systems and is composed of four discrete sub-modules Machine Architecture, Databases, Operating Systems and Networks. The sub-modules are taught consecutively and assessed separately. To achieve a meaningful understanding of the concepts covered in the module students must apply a deep learning strategy [1]. We believe that concept maps introduced and used within the lectures of the module, will support students to achieve a deeper understanding of distributed computer systems. The funding for concept modelling software and a personal digital assistant (PDA) to enable experimentation with different styles of concept modelling techniques on a small range of hardware devices was provided by Durham University's 'Enhancing the Student Learning Experience Awards'. The Centre for Excellence in Teaching and Learning Active Learning in Computing (ALiC) has purchased a large number of PDAs for exploring the use of mobile technologies in learning. We used these PDAs with interactive lecture software as a free-text response system. We have introduced three variations of the development of concept mapping: expert developed, cohort developed, and incrementally developed over successive lectures.

1.1 Concept Maps

Biggs [1] recognizes the usefulness of concept modelling techniques as an aid to deep learning. Concept maps are a graphical representation of knowledge within a specific domain. Concepts are represented by labelled geometric shapes, each representing a single concept, linked by labelled lines which illustrate the relationships between the concepts. The overall structure of the map conveys meaning as to the concepts relationship with each other and within the domain [2-4]. Concept maps support a deep learning strategy as they force students to scrutinize concepts and the associations between different concepts [1, 5]

Concept maps are a versatile learning tool as they support the capture of the tacit knowledge held by experts and the means of sharing that knowledge with students [3]. Concept maps generated by experts within a domain are expected to accurately depict the concepts and their associated relationships. Concept maps developed by experts in a domain have been proven to be good study aids [3, 6].

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission.

© 2008 Higher Education Academy

Subject Centre for Information and Computer Sciences

However, study materials prepared by a lecturer have a lecturer's imposed structure. Horgan [7] maintains students will learn more when allowed to structure their own understanding of the domain. Students may take a great deal of time to develop a concept map because often students will have to be trained in the practice of using and developing concept maps while trying to gain a deep understanding of the domain [3, 6]. Wingate [8] advocates embedding the teaching of study skills in the teaching and learning of subject content. For the Computer Systems module this meant using the concept maps initially as a study aid and to demonstrate expert knowledge then ensuring that students were able to add their own understanding to their personal copy of the concept map. Students need to be helped to recognise that concept maps are never finished [6] but instead are something that can be modified and grown as understanding of a domain increases. By allowing students to download and control their own version of a concept map, they can decide the rate and extent of growth of their own concept maps.

Collaboration is a key part of the constructivism theory of education where working with peers and contributing to a community's learning will improve the depth of an individual's learning [9]. A learning community's knowledge should be developed in a democratic manner where everyone has the right to access, correct, and increase the community's collection of knowledge [10]. Concept maps can be used to capture and share the knowledge held by a community of learners. A central concept map developed by the community can be used to share understanding. However it must be recognised that the shared understanding does not impose agreement or compromise [4]. Individuals within the community need to be able to structure and control their own knowledge and therefore need to develop their own version of a concept map developed by a community of learners.

A concept map can represent only so much knowledge [3] and it may be sensible to provide concept maps that can support additional objects, for example links to more traditional text information, podcasts or other concept maps. The software used to support the creation and continual development of concept maps in this work has mechanisms for linking to additional learning objects (video, text documents, and web pages) without detracting from the visual clarity of the concept map.

Inspiration [1] has been developed to support people building graphical representations and visual structures of their knowledge. It provides facilities to build concept maps as well as a mechanism to translate from text to diagram or diagram to text to aid those people who prefer text-based learning. It also provides mechanisms for linking to additional knowledge objects such as videos or web sites. Inspiration version 7.5 is available to our students through the university network.

1.2 Interactive Lecture Software

Lectures are a proven means of providing background information and discipline-specific concepts to students who are new to a discipline and do not, as yet, have the learning skills necessary for study at a higher education level [7]. However, lectures are considered difficult learning environments. Lecturers use a range of methods to increase student engagement during lectures including 'guided notes' [11] which encourage students to focus on specific concepts; and 'interactive windows' [12] where lectures have pre-determined breaks to allow students time to work on problems or exercises. One of the difficulties in providing in-lecture exercises is determining the level of success achieved by students. Deep learning is improved in lectures where lecturers can adjust the pace and content to reflect the students' needs [13].

On-line sets of Multiple Choice Questions (MCQs) have proven useful for providing students with quick formative feedback [1]. Higher education (HE) virtual learning environments (VLEs) usually provide facilities for lecturers to develop MCQs for use by students wishing to assess their own abilities [14]. Personal response systems (PRS) expanded the use of MCQs, allowing lecturers to set MCQs as in-lecture exercises that capture and display the students' responses during the lecture. Lecturers can use the responses to support students' deep learning with timely feedback and correction of misconceptions [13]. A richer, more meaningful dialogue could occur if the PRS provided a mechanism for less controlled responses, for example a response-mechanism that would allow students to respond using their own words.

The arrival of wireless technologies in HE Institutions has enabled the use of mobile technologies such as PDAs and laptop computers anywhere on campus including lectures. The wireless infrastructure enables students to access learning materials anytime and virtually anywhere [15]. ALiC has purchased a large number of PDAs to explore the use of mobile technologies in learning. We have used some of the PDAs to mimic student-owned mobile devices that would allow students to provide lecturers with spontaneous text responses to questions posed during lectures.

WIL/MA (Wireless Interactive Lectures/ Mannheim University) an open source software [16] was developed to allow the lecturer to get instantaneous feedback from the students to see if they had understood the concepts

[1] Inspiration Copyright 1988-2006, Inspiration Software Inc.

under discussion. Interactive lecture technologies are generally accepted as a good way of maintaining student attention and supporting student assimilation of knowledge within lectures[17]. The software is fully programmed in Java and has versions that run on PCs and PDAs. We were able to use the PDAs to allow students to: anonymously respond to preset multiple choice questions; use the SMS facility to respond to preset questions using free-text; ask impromptu questions based on earlier question/response exchanges; and gauge the opinions of the students using a feedback slide meter. In addition, the software WIL/MA has a mechanism that can allow the lecturer to select whether or not they want to share the collection of responses with the students. For example a lecturer may want to ascertain how many different examples of a concept a class of students would supply when not specifically challenged to find different examples. The PDAs used are not single purpose devices and, like any student-owned mobile device, contain software that can distract students from the lecture if the students choose to be distracted.

2. EXPERT DEVELOPED CONCEPT MAP

The first sub-module to be delivered in the Computer Systems module is Machine Architecture; a sub-module intended to introduce the students to concepts such as Boolean algebra, logic circuit design, binary arithmetic, and computer hardware.

2.1 PDAs and WIL/MA

Lectures in the Machine Architecture sub-module usually include one or more in-lecture exercises for students to perform and then compare their answer to a model answer supplied by the lecturer. Students will interact with peers while working on the in-lecture exercises. However, exchange of insights is usually confined to students sitting near each other. The lecture rooms are structured so that a lecturer cannot walk around looking at student work making it difficult for the lecturer to determine if the class is ready to progress. This lecture environment afforded an opportunity for an initial trial of the PDA hardware with WIL/MA. It was decided the initial trial would occur over a single lecture. We designed four multiple choice questions based on the in-lecture exercises intended for the lecture. As the students have a tendency to engage with their peers while working on in-lecture exercises, we decided to provide PDAs primarily to pairs of students. We distributed 39 PDAs to the 68 students in the lecture. A member of ALiC acted as observer during the trial, thereby allowing the lecturer to focus on the delivery of the lecture and the exchange with the students. Another member of ALiC was given the responsibility of liaising with students to get the PDAs distributed and running. It was explained to the students that this was a trial to see if the technologies would hold up in a live lecture and that they should be prepared to hand back the PDAs quickly if the trial had to be abandoned.

It took eight minutes to get all the PDAs active and connected to the university wireless network and calm the students down sufficiently to start the lecture. It was observed that initially the students' reaction to the technology was positive. Answers came from 32 PDAs for the first two multiple choice questions. Three PDAs had technical difficulties and four pairs of students had difficulty with the interface. The tally of the responses was shown on the screen at the front of the lecture room and it was possible to see that most students had achieved the correct result. It was also possible to correct the misconception that led to some students choosing the incorrect response. It was observed that a significant minority of students then disengaged from the lecture to explore the other software available on the PDAs. This caused some disruption to the lecture as students could exchange messages through the PDAs. One pair decided to play solitaire while another pair experimented with Bluetooth [2] technologies by uploading files from their mobile phone.

Those students who had not disengaged from the lecture were not rewarded for their efforts. The university wireless network had rebooted and closed the connections to all inactive PDAs. The capacity of the wireless network at the time was insufficient for our needs. Re-establishing the connections proved too disruptive and it was decided to abandon the trial in favour of completing the lecture.

Most Computer Science students enjoy the prospect of exploring new technologies. It might be that, once students are given the opportunity to explore the uses of the PDAs, the newness will fade and students will use them as intended during lectures. However, students using laptops in lectures are the minority in our Computer Science department and informal observations indicate that students are more likely to engage with software unrelated to the lecture occurring around them.

2.2 Concept Map

Level-one Computer Science students have a varying range of study skills that may or may not include the use and development of concept maps. Therefore an expert-developed concept map for the Machine Architecture sub-module was created and then demonstrated to students at the end of the last lecture of the sub-module

[2] © 2008 Bluetooth SIG, Inc.

and a week prior to the assessment for this sub-module. It was explained to the students that two copies of the concept map were available on the VLE, a static version stored as a Word document and a modifiable version stored as an Inspiration file. Students were invited to review the concept map, and download a copy to alter to suit their own learning. Students where told where to find the Inspiration software and its associated user support documents. It was explained that it was possible to translate the graphical concept map into a text based outline for those students who prefer text.

3. COLLABORATIVELY DEVELOPED CONCEPT MAP

The second attempt, using concept maps to improve students understanding of distributed computer system foundational concepts and the links between them, was done at the end of the series of Operating Systems lectures. We used interactive lecture technology, the PDAs and WIL/MA, to encourage the students as a community of learners to engage in the development of a concept map for Operating Systems. The map was developed a week before a written assessment exercise for the Operating Systems sub-module was due. It was intended that the development of the concept map and its subsequent use by individuals would contribute to an improvement in answers to two questions in the assessed work, which require students to understand several concepts and how the concepts link together.

Thirty-nine PDAs were distributed to pairs of students. A router, separate from the university network, was used in the lecture room to support the wireless technology and ensure that PDAs stayed logged on for the duration of the concept map development. It was estimated that it would take twenty minutes for the students to make a generous contribution to a concept map. The estimate was based on knowledge of the students' attention span and time constraints in the lecture schedule. A member of ALiC was asked to observe students during the exercise and another member of ALiC was given the responsibility of liaising with students to get the PDAs distributed and running while the lecturer focused on the dialogue with students. It was explained to students that the intention of the exercise was to develop a concept map that demonstrated their collective understanding of concepts within Operating Systems. It was further explained that there did not have to be complete agreement and that the lecturer would present a majority view for inclusion in the VLE that students could subsequently modify to reflect their individual knowledge structure.

The lecturer started the Operating Systems concept map with two Machine Architecture concepts (RAM and the CPU) and one Operating Systems key concept (the Process). There began a dialogue where the lecturer asked students for key concepts then, based on the students' responses, added concepts to the concept map. WIL/MA's SMS functionality allowed the students to send free-text responses via their PDAs in reply to the lecturer's questions. The dialogue continued and a concept map emerged that contained key concepts, labelled relationships between key concepts and some sub-concepts. The structure that emerged was web-like for key concepts and hierarchical in sections with sub-concepts.

The lecture room contained one screen that was used to display the evolving concept map. Students submitted short descriptions of key concepts quickly. The student responses were displayed on a laptop seen only by the staff in the lecture. The lecturer selected a description of a concept based on the submissions from the students. Students also responded quickly when asked to supply locations of links between key concepts. The submissions from the students slowed down and the number of participants decreased when the questions became more probing, for example meaningfully labelling the links between concepts.

Twenty minutes proved to be insufficient time to complete the map. The sub-concepts that had been submitted by students but not entered on the map were saved for later and used in the finished map. Generally, students' attention to the task lasted slightly less than twenty minutes. As the questions got more difficult, students disengaged and a significant minority began to explore the different software on the PDAs.

Informal discussions with students over the next two weeks indicated that they preferred submitting free-text response to selecting from predetermined responses. Staff and students both feel that more students would have responded to the more probing questions if example phrases from student responses had been displayed. It should be noted that it was difficult to regain control of the class after the concept mapping exercise.

4. INCREMENTALLY DEVELOPED CONCEPT MAP

For the final sub-module, Introduction to Networks, a concept map based around the 5 Layer Internet model was used at the start of lectures. The concept map was used as the foundation for a summary of concepts discussed in previous lectures. The map grew incrementally over the 10 lectures. Students were encouraged to comment and contribute to the development of the concept map. However, we did not use the PDAs as they take a significant amount of time out of a lecture to distribute and retrieve. Contributions from the students were few.

5. RESULTS

Analysis of the impact of the concept maps on students' achievement in the module will be based on the results from the questionnaire that was distributed to students at the end of the final term, and the detailed analysis of several pieces of assessment including the end of year exam.

Students were asked to complete a short questionnaire about their use and adaptation of the concept maps at the end of the final term. There were 57 replies to the questionnaire (84% of the cohort). Of those that replied, 28% have made use of one or more concept maps in their note taking or assessment preparation; 37% have not used them but indicated that they plan to use them as part of their revision for exams; 12% have opted not to use them; 2% have created their own; and 21% selected the 'What concept maps?' option on the questionnaire. Only two students copied and personalized one or more of the concept maps.

6. FURTHER WORK

The collection and analysis of the rest of the data associated with the module will be completed over the summer. Decisions on the further use of concept mapping in lectures will be based on the outcome of the data analysis. Decisions on the further use of the PDAs to elicit free-text responses from students will be based on the confidential end of year module questionnaires and comments made by students to the departments' Staff Student Consultative Committee.

7. REFERENCES

1. Biggs, J., *Teaching for Quality Learning at University*. Second ed. 2003, Maidenhead: McGraw-Hill House. 309.
2. Nesbit, J.C. and O.O. Adesope, *Learning With Concept and Knowledge Maps: A Meta-Analysis.* Review of Educational Research, 2006. **76**(3): p. 413-448.
3. Rewey, K.L., et al., *Effects of Scripted Cooperation and Knowledge Maps on the Processing of Technical Material.* Journal of Educational Psychology, 1989. **81**(4): p. 604-609.
4. Freeman, L.A., *The power and benefits of concept mapping: measuring use, usefulness, ease of use, and satisfaction.* International Journal of Science Education, 2004. **26**(2): p. 151-169.
5. Van Zele, E., J. Lenaerts, and W. Wieme, *Improving the usefulness of concept maps as a research tool for science education.* International Journal of Science Education, 2004. **26**(9): p. 1043-1064.
6. Novak, J.D. and A.J. Cañas, *The Theory Underlying Concept Maps and How to Construct and Use Them.* Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Florida Institute for Human and Machine Cognition, 2008.
7. Horgan, J., *Lecturing for learning* in *A Handbook for Teaching and Learning in Higher Education Enhancing Academic Practice*, H. Fry, S. Ketteridge, and S. Marshall, Editors. 2003, Korgan Page Limited: London, UK. p. 75-90.
8. Wingate, U., *Doing away with 'study skills'.* Teaching in Higher Education, 2006. **11**(4): p. 457-469.
9. Holmes, B. and J. Gardner, *E-Learning Concepts and Practice*. 2006, London: SAGE Publications Ltd.
10. Mason, R. and F. Rennie, *ELearning The Key Concepts*. Routledge Key Guides. 2006, Abingdon, Oxon: Routledge.
11. Heward, W.L., *Want to Improve the Effectiveness of Your Lectures? Try Guided Notes.* Talking About Teaching Essays by members of The Ohio State University Academy of Teaching, 2001.
12. Huxham, M., *Learning in Lectures: Do 'interactive windows' help?*, in *Napier University Staff Conference: Engaging our Students*. 2003, Napier University: Edinburgh.
13. Draper, S.W. and M.I. Brown, *Increasing interactivity in lectures using an electronic voting system.* Journal of Computer Assisted Learning, 2004. **20**: p. 81-94.
14. Clark, I. and P. James. *Blended learning: an approach to delivering science courses on-line*. in *Proceedings of the Blended Learning in Science Teaching and Learning Symposium* 2005. University of Sydney, Australia: UniServe Science.
15. Beetham, H. and R. Sharpe, *An introduction to rethinking pedagogy for a digital age*, in *Rethinking Pedagogy for a Digital Age Designing ad delivering e-learning*, H.B.a.R. Sharpe, Editor. 2007, Routledge: Abingdon, Oxon. p. 1 - 10.
16. Scheele, N., *The Interactive Lecture: A new Teaching Paradigm based on Pervasive Computing*, in *Faculty of Computer Science*. 2005, University of Mannheim.
17. Low, A., *A Technical Report Looking at Technology to Support Interactivity in Introductory Programming Lectures*, in *Technology Enhanced Learning*. 2008, Technology Enhanced Learning Research Group, University of Durham.