Abstract

This study was conducted during 2011 at an Australia university with a cohort of 93 undergraduate science communication students. Students worked in small groups of three or four to develop their knowledge in Biotechnology, Genetics, Virology and Ecology by constructing digital knowledge maps, which are visual representations that show ‘at-a-glance’ the key ideas and their connections of any given topic. Their construction necessitates subject matter knowledge and conceptual understanding, with students required to use analytical, problem solving, negotiation, communication and team working skills. Findings indicate that the open-ended nature of the mapping activity gave students great control and ownership while cultivating life-long learning skills.

Keywords: digital knowledge maps; undergraduates; collaborative learning; life-long learning skills

1. Introduction into digital knowledge maps

Knowledge maps also known as cognitive maps are graphical representations in which ideas or words are placed in so-called nodes. These are connected with lines that can indicate uni- or bilateral directions (through arrows), which are called vectors. Linking words can be added to the vectors to show the interrelationship between various nodes.

In this paper, the term of knowledge maps will be used to collectively refer to both mind maps and concept maps. They can be either constructed manually (with paper and pen), digitally (on a desktop computer, netbook, tablet), individually, in pairs or collaboratively in small or large groups.

Mind maps use a central word, idea or other item and arrange others intuitively around the central word. A mind map starts with a key notion that radiates out into branches. These tree structures set up a non-linear graphical arrangement, which promotes brainstorming. This free flow of ideas generates and charts elements without the immediacy of having to establish
an intrinsic conceptual framework (Ng & Hanewald, 2010, p 82).

Figure 1: Example of a basic mind map

Mind maps are excellent tools to jot down an idea clearly and quickly. They can form the basis for a concept map, if they are modified to indicate hierarchies between key notions.

Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts (Novak & Cañas, 2006, p. 1).
Concept maps are ideally suited to the teaching and learning of science topics, as complex issues can be unpacked and displayed in visual form to indicate knowledge and conceptual understandings.

Digitally created knowledge maps are superior to those drawn by hand as the electronic version allows for gradual building and constant modifications without the messy, cumbersome and time consuming task of erasing or writing over a manually drafted map. Digital iterations enable numerous, quick changes with the option to save numerous successive versions, import them into word documents or power point presentation to be replicated, projected to audiences or emailed to others for their alterations.

Specific software is available for free (i.e. CAM editor, Compendium, Free mind, Freeplane, Sciplore Mindmapping, WikkaWiki, VUE, XMind) or through proprietary (commercial) software such as Creately, Inspiration, LucidChart, Microsoft VISO, Mind 42, MindMapper, 3D Topicscape, Qiqqa, Prezi or MindMeister, which can be used via an iPhone or iPad. Online applications such as C-map tools (http://cmap.ihmc.us/) allow for collaboration of various users anywhere in the world, either through synchronous or asynchronous participation.

Digital knowledge maps allow for infinite changes to maps, thus giving users great control and flexibility in their gradual construction. Apart from the constant changes to textual chunks to reflect the growing knowledge and understandings of the subject matter, modifications can include the colour, font, size and shape of the nodes, their content, the vectors and their linking words to indicate clusters of sub-themes and relationships.

Other features of digital knowledge mapping software or online applications may include the addition of voice recordings (sound files) to explain particular aspects, the insertion of still or moving images (pictures or video clips), the incorporation of web site links and 3 D views.

Literature review

Although the technique of concept mapping was developed in the 1970s by Joseph Novak (1990,1991), electronic concept mapping (through self contained software packages on individual computers) has been available to the public for merely two decades that is after the invention of personal computers. The development of more powerful computers, the Internet and Web 2.0 tools has made collaborative online mapping option a possibility for about the last decade or so. Hence, there is currently only a limited body of knowledge available on the use of digital knowledge maps for teaching and learning, especially in tertiary setting. Emerging publications range across disciplines (Education, Science, Business, Medicine, Law) with very few focusing on the cultivation of life-long learning skills. However, these are essential as they underpin the acquisition of any subject matter.

Ifenthaler, Masduki and Seel (2011) used online mapping (C-Map Tool) with 25 students and found that it was useful in facilitating knowledge sharing amongst them. The researchers argued that learning and retention of new materials is unstable, chaotic and ambiguous without sophisticated cognitive skills. Such skills are identifying, gathering, evaluating and using information facilitate the learner’s organization of materials, help identifying any knowledge gaps and integrating new materials into existing knowledge.

In their study of students constructing computer-supported concept maps for a university unit of hibernation and thermodynamics, Schaal, Bogner and Girwidz (2010) were able to show the acquisition of higher order knowledge structures. These are more sophisticated than the simple memorization and recall of facts or information that is typical to rote learning, as deeper understanding of the learning material is required.

Life-long learning skills such as working collaboratively in teams, communicating and negotiating ideas with others in the group were a dimension of computer-generated knowledge maps as investigated by Kwon and Cifuentes (2009). They found that working with others compared to working on their one provides for rich discussion which advanced the students’ analytical and argumentative skills.

2. Methodology

The study commenced at the beginning of 2011 with a group of 118 Undergraduates undertaking a Science Communication unit. The unit was taught by four different academics across six separate tutorials, with approx. 30 students in each. Due to absences and incorrectly filled out Informed Consent Forms, only 93 students were able to participate in the survey. The paper based survey contained eight questions (multiple choice, 5-point Likert scale and optional commenting). Of the 93 students, all granted their permission to use their knowledge maps (in the
initial and final version) and the associated group reflections. Unrelated and prior to the commencement of the research, the science concept maps and related reflections were designed as mandatory, assessed pieces of work for the Science Communication unit for some time, with these assignments counting towards the students’ final mark. It was therefore seen as crucial, that the data would be collected by an independent research fellow, who was neither involved in the teaching, nor the marking for this or any other unit to prevent any pressure on student to participate. This impartiality, lack of prior and future association of the researcher with the students enabled them to speak freely during interviews while ensuring confidentiality and anonymity without fearing repercussions. The interviews were scheduled after the completion of the course work to gauge students overall experience. However, the timing clashed with other assignment deadlines within the degree and due to those commitments and the resulting lack of time or interest, only a small number of students volunteered. Nevertheless, those that did participate in the semi-structured audio-recorded interviews provided rich and significant additional perspectives.

The research questions aimed to explore the development of life-long learning skills such as

A.) Critical analysis, problem solving, and creative thinking
B.) Identifying, gathering, evaluating and using information
C.) Communicating effectively and appropriately in a range of contexts
D.) Developing, planning and managing independent work
E.) Working effectively as part of a team
F.) Effectively using Information and Communication Technologies (ICT)
G.) Applying knowledge in the program to new situations

As indicated, small groups of students (usually 3 or 4) used digital concept mapping to produce their collaboratively created graphical representations. The multiple choice question 6 of the survey gauged their experience in doing the knowledge maps, with findings presented in Figure 3 below.

![Figure 3: Students experience in doing knowledge maps](image)

More than half (53%) of the undergraduate cohort (49 out of 93 students) stated that the experience of doing knowledge maps helped them think about their topic while less than 10% (9 out of 93 students) thought it to be a waste of time. While 2 students thought it to be difficult, almost a third of students (28 out of 93) thought it to be straightforward. A total of 6 students gave no reply.
Students worked in small team of three or four to increase their science knowledge, specifically Biotechnology, Genetics, Virology and Ecology. For their group work, they choose topics such as Genetically Modified Foods, Designer Babies, Nuclear Power, Life in Space, Diabetes, Psychosis vs. Psychopathology, etc. The latter topic is displayed in the knowledge map below with the associated reflection as a typical example.

![Knowledge Map](image)

**Figure 4: Student generated knowledge map on Psychosis vs. Psychopathology**

The knowledge map illustrates how students used their learning skills to interpret, develop, share, reinterpret and present this particular topic. Working in groups also required members to negotiate, plan, coordinate and manage their independent and collaborative work components. Other life-long learning skills include the effective use of information and communication technologies and the capacity to transfer newly gained knowledge in different contexts. Students’ written group reflection generally contained the reasons for choosing their topic, a brief summary of the overall design of the knowledge map and the process of constructing it. The student who worked on the map in Fig 3 indicated the following:

Students’ written group reflection generally contained the reasons for choosing their topic, a brief summary of the overall design of the knowledge map and the process of constructing it. The student who worked on the map in Fig 3 indicated the following life-long learning skills, previously numbered above as research questions from A to G, which were inserted in the student generated text to clearly indicate awareness and cultivation.

[...] our map starts with the medical and technical differences between psychosis and psychopathy; with their inter-correlating issues provided in our concept map [...] the team members divided the workload [D,E], communicating [3] often thru the use of mobile devices [E, F] as well as frequent meetings on campus to discuss the structure, design and content [A,B,C,D,E]. The authors collaborated individually through their personal computers [E,F]as well as at the university’s computer labs [E,F,] to create, edit and finalise this project [B,C].
This comment was typical and thus more or less representative of those produced by other groups, indicating the students starting point and the process through which they developed their life-long learning skills. These narratives were further validated by the results from Question 7 of the survey, which consisted of a 5-point Likert scale (see Figure 5 below).

![Figure 5: Students’ thoughts on a range of life-long learning skills](image)

Most of the 93 students thought at the end of the unit that they extent to which they had the skills (A-G) was ‘good’, ranging from 62 students (67 %) for A, (60 for B, 54 for D, 53 for E, 51 for F, 59 for G) to 48 students (52 % ) for C. Almost a third of the students thought that their extent of the (A-G) skills was ‘okay’, approx a sixth of students thought it was ‘excellent’, only a minority (about 2 %) thought it was ‘poor’ with ‘negligible’ gaining no traction at all. Skill C (Communicating effectively and appropriately in a range of contexts) obtained the highest overall score, with skill D (Developing, planning and managing independent work) gaining the lowest overall score.
3. Conclusion

Findings were generated from the knowledge maps themselves (comparing the initial draft to the final map), their reflections on the process and product, surveys, semi-structured interviews with students. The survey indicated that most students found the experience of using digital knowledge maps positive and more than half of the student cohort indicated that using knowledge maps helped them in thinking about their topic. It further revealed that students thought that they had a range of life-long learning skills (critical analysis, problem solving and creative thinking; identifying, gathering, evaluating and using information; communicating effectively and appropriately in a range of contexts; developing, planning and managing independent work; working effectively as part of a team; effectively using information and communication technologies and applying knowledge in the program to new situations) at the end of the unit. On a 5-point Likert scale, students rated the development of those skills as mostly ‘good’, followed by ‘okay’ and ‘excellent’, with a trivial mention of ‘poor’ and no indication of ‘negligible’.

Knowledge maps are generic in nature, which makes them suitable for use in any discipline and for any topic. The open-endedness of digital knowledge mapping combined with the gradual building and constant modifications of online iterations give users great control and ownership of their learning. The mapping activity involves the application and subsequent cultivation of life-long learning skills such as the generation and communication of ideas, the ability to research, independent and analytical thinking, analysis and synthesis of information, working collaboratively with others and the effective use of information and communication technologies.

4. Acknowledgements

The author would like to express sincerest thanks to the students participating in this research project. Many thanks also to Deakin University’s Faculty of Arts and Education who supported this work with a Teaching and Learning Grant in 2011. Thank you also to Institute of Human and Machine Cognition (IHMC) Florida, USA for providing C-map tools free of charge.

5. References


