Using Concept Maps to Integrate Hierarchical Geographical Concepts for Holistic Understanding

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Abstract

Concept maps can be a powerful learning tool for an interdisciplinary subject like geography in which the integration of progressively developed concepts, the incorporation of field experiences and data, and the integration of location specific applications of learned concepts require a holistic understanding of otherwise potentially segregated geographic processes. Two university courses in Physical Geography were introduced to the use of CmapTools in an effort to integrate various classroom-based and field-based knowledge and develop a meaningful, holistic understanding of many related concepts. The goal of this strategy was to emphasize the much desired connectivity among the many facets of this interdisciplinary subject domain as well as to integrate knowledge disseminated at various levels of undergraduate training. The outcome indicates that learners, when provided with adequate exposure and environment, use the concept mapping tool effectively to integrate hierarchical geographic knowledge. Learners also found it a satisfying and useful learning experience.

Keywords: Concept maps, CMap tools, conceptual learning, hierarchical knowledge organization, integrated knowledge

Introduction

Geography is an interdisciplinary subject with many concepts straddling various sciences that enables us to understand the environment on Earth and how it is linked to the human dimensions of the world. Learners need to have a holistic understanding of the spatial contexts of people, places, and environments. Many geographic processes, therefore, require the learner to link multiple concepts in order to develop a holistic understanding which is supported by Wiggins and McTighe's (2005) much discussed 'Big Idea.' According to Wiggins and McTighe (2005), a 'Big Idea' may be a concept, theme, or issue that gives meaning and provides connection to discrete facts and skills related to the environment and the operating processes therein. As a discipline, geography also requires learners to integrate and apply learned concepts, to examine and assess field observations and specific case studies thereby providing the much required real life relevance to learning. This requirement for an integrated understanding creates a niche for a system that provides the learner a platform to park previously learned concepts, direct field experiences, case studies, and various relevant resources for reorganizing them in order to integrate an understanding of the issue at hand. A concept map (Cmap) can be said to be a knowledge model which is represented as a labeled set of nodes and arcs used to summarize a body of knowledge on a topic. Each node typically represents a concept, and an arc between two nodes represents a relationship or link between two concepts (Hanson, 2005). CmapTools (Novak & Cañas, 2004) is one concept mapping software that was deemed suitable for initiating and supporting dynamic knowledge construction, integrating concepts, and organizing acquired knowledge into hierarchical formats which allow multilayered concept organization in the learner's mind. The CmapTools software environment, developed at the Institute of Human and Machine Cognition (IHMC), empowers users to construct, navigate, share, and criticize knowledge models represented as Cmaps. The toolkit is platform independent and network enabled allowing the users to build and collaborate asynchronously during the construction of concept maps with others anywhere on the network. Users can also share and navigate through others' models distributed on servers as well as progressively build up a resource base to assist in understanding and concept building. This concept mapping tool was used in two undergraduate geography courses for this study. The courses chosen were a Second Year course in Biogeography (AAG232) and a Third Year course in Catchment Management (AAG331). The rationale for choosing these two courses lies in the very character of the two subjects. Biogeography is an interdisciplinary subject which draws on concepts from geomorphology, hydrology, biology, and soil science which are courses that are covered by learners prior to taking up this course. Catchment Management is an application course that builds on previously gained knowledge of geomorphology and hydrology concepts and requires application of those concepts for examining catchment management issues. Therefore, both of these courses were ideal for integrating and mapping many concepts learned earlier as well as during the respective courses in order to bring relevance and create a holistic understanding of issues.

The objective for using the concept mapping technique was to facilitate a holistic understanding of interrelated concepts and to incorporate knowledge gained through classroom-based lecture-style and lab-based experimental-style learning, field-based enquiry, group work, and self exploratory methods. At the end of the course, learners were expected to draw relevant Cmaps using CmapTools software with appropriate nodes and linkages in order to link previously acquired knowledge from earlier and other related geography courses, available resources, their own research, and group fieldwork investigation (i.e., surveys, data, observations). This was done in order to reveal their holistic understanding of the environment and its interrelated processes and to also perform an effective analysis of geographical issues.

Why use CmapTools for Concept Mapping?

As De Simone, Oka, and Tischer (1999) point out, it is assumed that college/university learners are proficient readers. However, in line with other findings (Bransford, 1979; Novak and Gowin, 1984; De Simone et al., 1999), as well as from the author's personal experience, it may be reaffirmed that such learners are still not proficient enough to abstract information and formulate a coherent understanding of interrelated issues. Much of the learning remains as separated nodes or bodies of knowledge without any integration or organization and, learners find it difficult or are reticent about integrating previously acquired knowledge with currently acquired knowledge to solve problems. Modular systems followed in the universities serve to create this artificial segregation among originally interrelated disciplines. Unless conscious efforts are made to integrate the various learning objects, the learner goes through the courses without comprehending the interconnectedness that exists among the various concepts within the various courses and concepts in geography.

In the course of planning the curriculum and subsequent delivery, such integration may be intended. Unless the learner is made to have the experience of integrating himself/herself, much of this effort on the part of the curriculum developer/facilitator is lost. One example is the spiraling system of curriculum which takes a student in Physical Geography at the university (National Institute of Education, Nanyang Technological University, Singapore), from First to Third Year, similar to other universities in the world (Figure 1). Prerequisites are emplaced to ensure that learners come to class with the required prior knowledge to be able to assimilate and organize their prior experiences for more effective learning experiences in subsequent courses. However, since the courses are delivered in separate self-contained modules, learners tend to process information as discrete units rather than a linked continuum of knowledge as is intended in the curriculum. This leads to less than optimum learning integration.

It is common to find that learners focus on topics covered in the current course to analyze a given problem but do not use or assimilate pre-acquired knowledge with current knowledge. For example, when asked to perform basic mathematical calculations for stream flow analysis, learners in a Second Year Geomorphology course found it daunting as calculations of that nature are only thought to reside in math courses. Such levels of mathematical abilities are quite within their capability, however, because they have been through compulsory math at the secondary and pre-university levels. Many learners ask if they are 'allowed' to use knowledge they have acquired in biology courses when researching mangroves or rainforests in a biogeography course. This shows the compartmentalization of knowledge even when such responses are not intended in the curriculum.

Geographic learning also requires learners to apply their knowledge from more than one discipline to analyze real life environments. During field work, learners are required to apply their prior knowledge from all related disciplines, carry out investigations, and also analyze the collected data. Very often, however, the learners tend to disregard the connections between previously learned concepts and focus on the current course content alone to process information as a distinct unit outcome, rather than as linked ideas. This leads to less than optimum learning as well.

Year One:
Introduction to Physical Geography
(Pre-requisite to take Physical Geography courses in Second Year)

Year Two:
Geomorphology (Semester One)
Biogeography (Semester Two)

Year Three:
Catchment Management
(requires students to take Geomorphology in Second Year)

Figure 1. Structure of courses in Physical Geography from First Year to Third Year.

The present study aims to look at, 1) how learners can be encouraged to incorporate what they have learned in previous courses and, 2) how to analyze what they observe in the field to answer a focus question which is aimed at providing a holistic understanding of the issues under study. This was done through the use of field investigations and field data collection in the Biogeography course, and in the Catchment Management course, case studies were used to help learners use and organize their past knowledge. Both groups were involved in organizing the knowledge through concept maps using CmapTools to draw up the 'Big Idea' and establish the linkages. Fensham, Gunstone, and White (1994) mention that conceptual change is often an accretion of information that the learner uses to sort out contexts while Gunstone and Mitchell (1998) propose that conceptual change is coordinated with the learner recognizing, reconstructing, reviewing, and restructuring relevant aspects of their understanding in a way that provides coherent consistency in learning. These required cognitive actions are essential to making sense of field-derived and case-derived components. Thus, it was perceived that such exercises provide a suitable platform to initiate learners to learn through concept mapping in order to develop a more complete geographic understanding.

As Novak and Gowin (1984) point out, concept mapping is among the most promising methods for promoting relational, conceptual change where learners make use of various symbols to determine the relationship between concepts. Such concept maps have been in use in all facets of education and training to foster learning (Novak & Cañas, 2004). Concept maps are hierarchical diagrams that provide a graphic display of interrelationships among concepts. As mentioned in Geography for Life, "the power … of geography allow(s) us to see, understand, and appreciate the web of relationships between people, places, and environments" (Geography Education Standards Project, 1994, p. 29). For the present study, the learners from the two courses used concept mapping to understand and establish this 'web' of relationships among concepts and demarcated the 'to and from' links to indicate the linkages.

Methodology

The study adapted the CmapTool-based learning activities model used by Novak and Cañas (2006) to incorporate several stages of the conceptual development and integration (Figure 2). The restructured model shows the various components of activities supported by the exercise and is classed as (1) scaffold, (2) student-led research, (3) student-generated resource building, (4) student-led exposition, and a final outcome, (5) multidisciplinary conceptual integration and understanding (Figure 2). At the end of the course each student-group created a digital portfolio using the CmapTools and shared it during cooperative learning.

Following Vygotsky's (1978) idea of 'Zone of Proximal Development,' which is supported by the Novak and Cañas' (2004) model, some opportunities for a higher level of understanding were provided by the lecturer to all learners in the class through the common lectures, lab sessions, and assignments. This was required to ensure that all learners started with the same and essential conceptual background and it was a level playing field for all. The

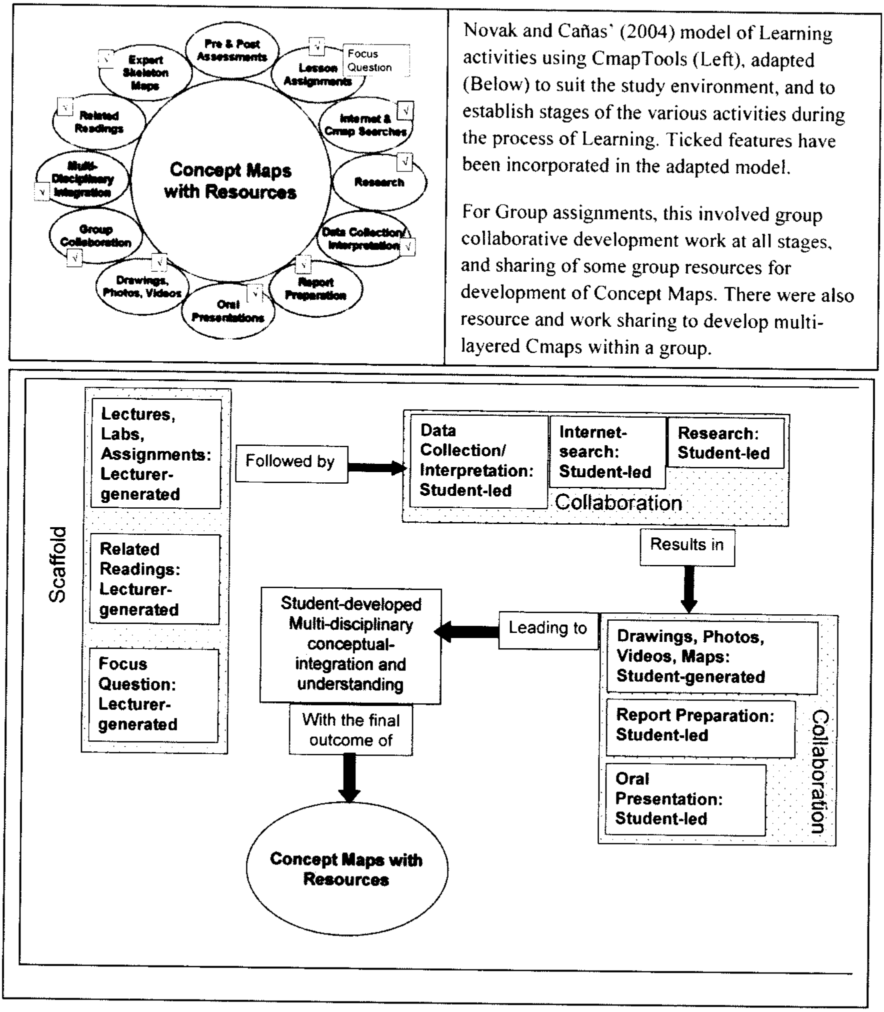

Figure 2. Spectrum of Learning Activities for the study, based on Novak and Cañas' (2004) model.

focus question generated by the lecturer provided the direction. According to Bransford et al. (1999), this is an idea also confirmed to have positive learning outcomes.

The scaffolding stage was followed up by student-led field and research activities. Students worked in groups to gather data and resource materials either directly from the field, from library-research of case studies, or both. Data and research materials were in line with the focus questions provided in stage one.

Student-led activities subsequently led to the generation of laboratory analysis reports, various graphic representations, such as maps, diagrams, images, written reports, and oral presentations, in the third stage of the activity. At this stage findings were shared, developed, and improved upon through classroom and Internet-based discussions.

After much negotiation occurred both within groups and among groups, the final outcome of the coursework was a concept map developed by each group. Acquired knowledge and interpretations were refined and finalized and concept maps were constructed with multiple nested layers that represented learners' understanding of the concepts and their interconnectedness with other concepts. The final concept maps also provided links to all resources (e.g., images, articles, notes, and annotations) that were arranged in a similar nested fashion thus categorizing and organizing the concepts as understood by the learners during these courses.

Justification for using the concept mapping technique lies in the fact that the discipline is more effectively delivered with graphic representations. This is the case for the knowledge structure as well as for the supporting resources that can be organized thematically and hierarchically. Graphs, maps, photographs, and other visuals, such as videos, are common resources used in geography (Balchin, 1976) particularly since this is a field-oriented discipline and, an effective way of bringing relevance to the topics is by using ample illustration and graphic representation of the quantitative components. The ability of CmapTools to organize concepts hierarchically is particularly useful as one geographic concept is built on several smaller concepts and together they form the big picture that the learner needs to assimilate in order to understand the interrelationships. The nesting, collapsing, and expansion of concepts when required are aspects of immense usefulness in geography. This may be referred to as the 'High Ceiling' capability of the tool as the individual concepts can be progressively developed and as the learner goes deeper into the learning environment (Cañas, Hill, Carff, Suri, Lott, Arroyo, Carvajal, Eskridge, Gómez, Arguedas, Granados, & Bunch, 2004). While a basic Cmap might only show one level of hierarchical linear development, a more advanced learner can continue to build up the concept map with many layers of added concepts, supporting resources, comments, etc., and the complexity of the understanding depends on how far the Cmap has been developed. Thus, a learner may be able to develop and redevelop the concept map as he/she goes through the course. This aspect was well used during the present study with learners developing, redeveloping, or reorganizing previously learned concepts (from other relevant courses). Students also incorporated previous knowledge as they went through the course. This framework for the assimilation and incorporation of previously learned concepts in order to develop new ones is in line with Ausubel's (1963; 1968; & Ausubel, Novak, & Hanesian, 1978) fundamental idea that meaningful learning takes place by assimilation of new concepts with the learner's existing concepts. The entire framework of the courses supports this idea of progressive spiral learning based on prior relevant knowledge (with the current courses based on the prerequisite foundation in courses in previous years). The requirement of classroom learning alongside direct observation, quantitative data collection in the field around some focus questions, and research into case studies that used an amalgamation of multiple concepts provided the impetus for making sense of real world environments. The learners were faced with the need to do their own research to suit the requirement of the focus question. It also allowed freedom to initiate new research and new ways of representing findings, all of which gave the much needed commitment and motivation for 'meaningful learning' with learner control.

Organization of the Coursework

Course work for both courses focused on progressive development of knowledge acquisition. In the first phase, present and prior learned concepts were connected in order to integrate their understanding of the biogeographical and geomorphological processes. The second phase integrated these relevant concepts to understand and assess a given real life environment from field observations and case studies. Both of the groups were given one assignment each for each phase as group endeavors. The learners negotiated together in pairs to revise and reconnect prior knowledge and also collectively worked on the development of the conceptual models to answer the given focus question. In both cases learners were asked to use CmapTools to develop the linked Cmaps using a computer. The outcome of the learners' work in the form of concept maps was, thus, prescribed for both courses. Links were developed by the learners after much negotiation during student led discussion sessions. The processes and phases followed throughout the courses incorporated conventional classroom processes with the student centered knowledge organization in order to create new and meaningful knowledge which is not just derived from real world situations, but also helps to develop knowledge dynamically that is closer to one's own experiences and, therefore, can be seen as more relevant (Figure 3).

The first assignment for Group 1 was to create the ground work to prepare for the more in-depth exposure to fieldwork. Subsequent links between

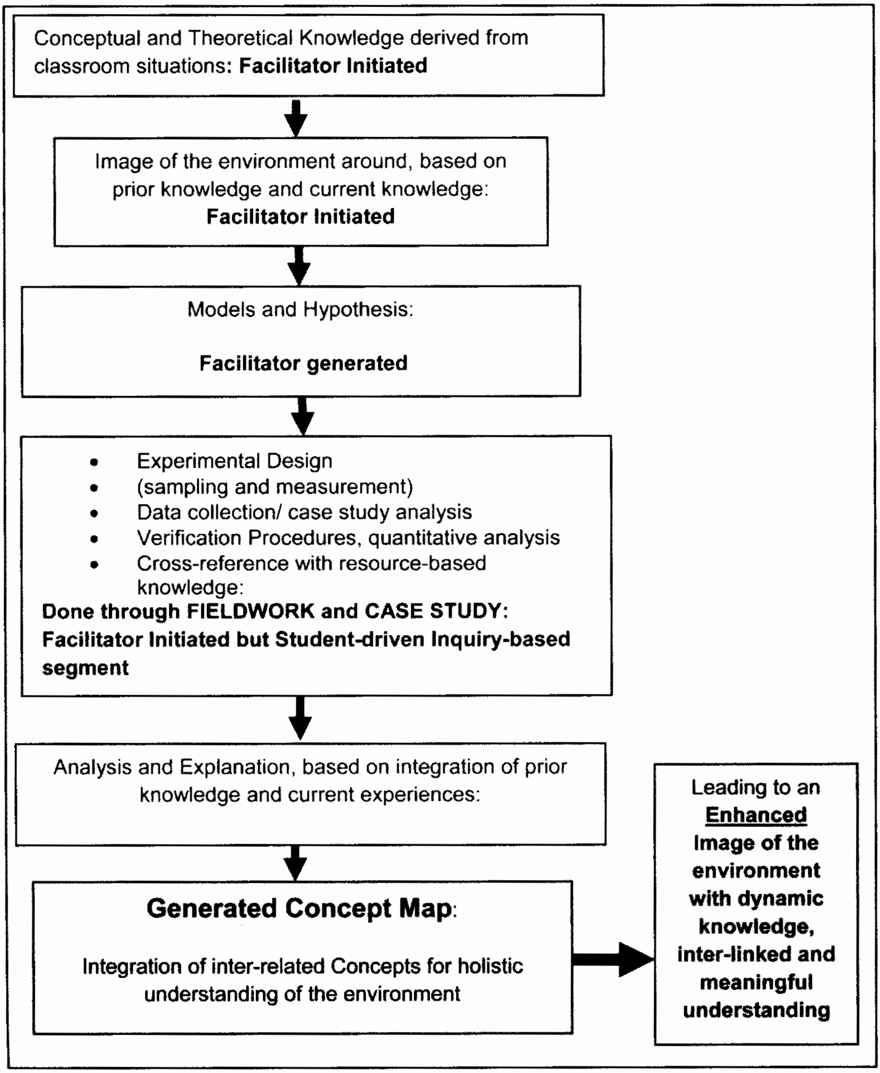

Figure 3. Flow of work during the courses to develop geographic understanding by using Cmap Tools.

previously learned theoretical concepts and subsequent laboratory analysis was expected through Assignment 2. The first assignment for Group 2 was related to the assessment of some controlling processes that impact the catchment environment in response to developmental activities in the catchment area. This required the members of Group 2 to find the interrelated nature of the various controlling factors with each pair concentrating only on one or two processes. During group presentations in class, the processes operating in the entire catchment were discussed and established through development of Cmaps. Linkages were established from the student's own research and intergroup findings during the discussion sessions. The idea was to illustrate the interdependences of all the processes in the catchment, which, in earlier courses were taught/learned separately. The second assignment was on case studies and the application of all relevant conceptual understanding was required to interpret the given environment.

Course design fieldwork and the case studies provided exposure to help generate the new image of the environment which was reflected through the Cmaps. Both courses aimed towards merging the theoretical and practical aspects to help learners be aware of the interconnectedness. The provision for linking words and the flexibility of CmapTools for multiple revisions and additions allowed for a spiraling development of ideas. Thus, the Cmaps were used as a continuum for the development of an explicit and holistic geographic understanding. The linked-meaning-making between the conceptual understanding and the explicit real world relevance was expressed using the Cmaps. It thus formed a vital link in the knowledge development of the learner. Such an integration of the real world within a cognitive framework enables learners to develop an awareness and relevance of geography and as Burt (1989) emphasizes, helps learners to gain a perspective within which they can place local, national, and international issues which have a geographical dimension. It may be said that there is a much needed '*Niche*' for concept maps to assimilate the various components of the given environment in order to understand and establish the links to create a deeper and self-driven meaning of the given environment by linking relevant learned concepts with the observed, researched, and analyzed information. The outcome is a higher level of cognition.

Vallega (2000) cites Buttimer's (1993) four approaches to the understanding of places and spaces: *ergon* (responding to social and scientific stimuli), poiesis (discovering and creating), *logos* (systemizing), and *paidaia* (educating). Vallega (2000) refers to these as the components of a '*mandala*' within which geographic education becomes increasingly important and includes impacts from society and science, uses globalizing tools, and shares experiences. Using this concept, the courses emphasized knowledge building and meaning making through the use of Cmaps. The Cmaps were progressively developed in stages and linked the knowledge outcomes of that stage of work with the previously learned concepts. It involved learning by stages and linking these stages through progressive development of Cmaps, thus dynamically creating a holistic geographic understanding from a shared fieldwork/ case study experience.

Processes and Stages of Work

Stage 1: Initial lectures, lab sessions, and some introductory readings were provided by the lecturer to introduce the various concepts related to the main theme of the courses following Ausubel's (1963; 1968; & Ausubel et al., 1978) idea of meaningful learning through assimilation of new concepts with the learner's existing concepts. Group 1 was given instructions on the biogeographical environment of a tropical rainforest while Group 2 underwent lessons in geomorphological and hydrological processes in a catchment basin undergoing urban development. This stage of knowledge development can be parked under the banner of Buttimer's *ERGON: response to stimuli.* Instructions were also given to draw up Cmaps for these courses using CmapTools introduced earlier in a previous course instead of a written assignment. The usefulness of concept maps in preparation for examinations was also pointed out. Learners were given the choice of using as many types of resources as they preferred and were asked to be creative in their productions. Similar instructional procedures were followed by Czuchry and Dansereau (1996).

Stage 2: Field work (Group 1) and case study research (Group 2) was done to investigate site specific details that corresponded to learned concepts. This led to the discovery of interdependent processes and creation of new artifacts, knowledge, dynamic meaning making of observed processes in a real world environment, and provided relevance to the concepts previously learned: termed *Poiesis*.

Stage 3: Logos or *systemizing of information* was achieved by organizing the collected information by doing lab analysis, data manipulation, graphing, research, and collating relevant information by all groups in both courses. The University's Learning Management System, BlackBoard, was used as a platform for organizing and sharing resources and information among the learners.

Stage 4: Paidaia or *educating stage* was achieved by both groups through development of Cmaps (using CmapTools) and by presenting these in the class for discussion. The learners shared their learning experiences, renegotiated their understanding of the respective studied areas, made connections with the findings of others, and as a whole, made meaningful connections to create a holistic image of the entire environment under discussion. One final Cmap that was developed in stages by a learner group is depicted in Figure 4. The final version shows the integration of prior knowledge, field experiences, course materials, and student's own research for developing the final holistic understanding and assimilation. Various sections were covered in the various courses and through lectures as well as the sections done through field and laboratory investigations and student research (Figure 4). The links created by the students to the different nodes of knowledge representing the various theoretical concepts and the field and laboratory experiences point to their holistic understanding of the issue. Clearly, this is an indication of knowledge integration. Finally, one extra achievement was the sharing of all Cmaps for future use and the possible reorganization of information.

Analysis of Student Responses

All learners using CmapTools for the courses under study were exposed to concept mapping and the CmapTools software in earlier courses conducted by the author. Therefore, all had some prior knowledge and experience regarding the process of both concept mapping as well as maneuvering within the

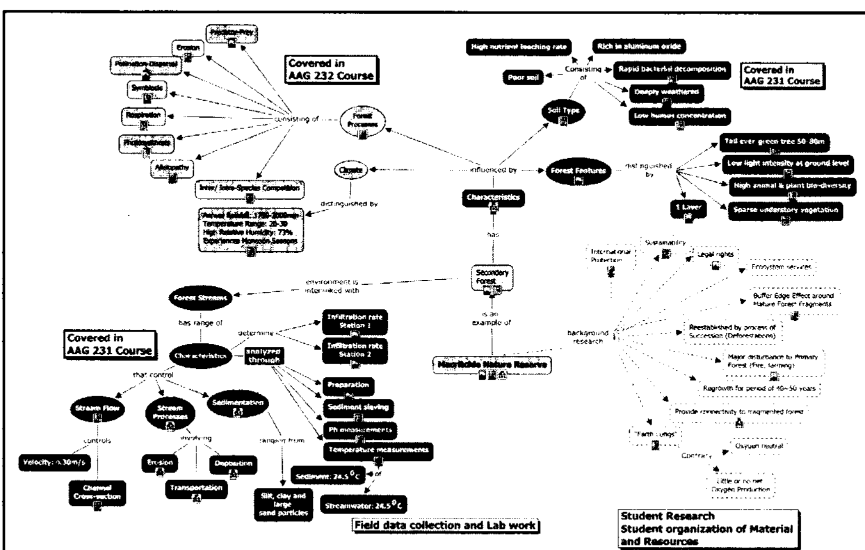

Figure 4. Cmap drawn by a student group showing the integration of prior knowledge, field experience, and their own research.

mapping environment. All learners were also exposed to various computer based learning environments. This ensured two things, 1) the learning curve, for most, was near flat and, 2) there was no novelty in the use of the software to cloud the learner's views on it. Some salient points came out from the anonymous student survey conducted after the course (Table 1).

The survey revealed that all learners found concept mapping beneficial to their learning and all felt that it was useful to organize their learning into 'smaller concepts' because they could be organized by nesting them inside 'bigger concepts' which indicated that the use of hierarchical knowledge organization was useful to them. While Figure 4 reveals all the nested views

Table 1

Student Views on the use of CmapTools and Concept Mapping as a learning tool. (Group 1 (Second Year students): n=16; Group 2 (Third Year students): n=6; Total n=22).

Observations by students	**Group 1 (n=16)**	**% of students**	**Group 2 (n=6)**	**% of students**
Prior knowledge and exposure to software and concept mapping	16	100	6	100
Easy to use	16	100	6	100
Some qualitative observations of students				
Learning the details of the software: **Self-exploration**	16	100	6	100
Easy to see the connections in the concepts	16	100	6	100
Shows the Big Picture	16	100	4	66
Sharing the concept maps helps	12	75	-	-
Helps Visual Learners	8	50	2	33
Helps Revision before exams	12	75	4	66
Links the smaller concepts together under a bigger concept, making understanding easier and more meaningful	16	100	6	100

Table 1 continued on next page

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Different resources from field work can be linked to concepts, providing relevance	16	100	5	83
Resources added: Photographs	16	100	6	100
Resources added: MS Word files	16	100	6	100
Resources added: MS Excel files	16	100	6	100
Resources added: PDF files	12	75	6	100
Resources added: Websites	16	100	6	100
Resources added: PPT slides	8	50	6	100
Resources added: annotations and comments	12	75	6	100
Resources added: animations/ video clips	8	50	2	33
Will use for future learning	14	88	4	66
Cooperative knowledge building through group work	12	75	4	66
Can be dynamically enhanced	8	50	-	-
Promotes creativity	6	38	-	-
Free to use	4	25	-	-
Supports Student-centred Learning	12	75	4	66
Negative aspects of CmapTools				
Some links are lost when moved from PC to PC	16	100	6	100
When nested nodes are opened, the whole picture looks messy	1	6	1	16
Prefer writing on paper than on PC	2	13	1	16
Very time consuming to develop and create the links	1	6	2	33
Negative aspects of Concept Mapping				
Prefer learning from texts	1	6	1	16

Table 1 continued on next page

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Prefer materials in PPT format/ Lecture notes	1	6	1	16
May not suit learning styles of all	2	13	2	33
Prefer using other learning techniques (did not specify)	1	6	1	16

together, the color coding shows the respective nodes. The multilayered structure of the various interrelated concepts helped learners to arrange information in manageable sizes. The nesting capability proved to be useful for learners as they progressively developed their knowledge and the interconnectedness was made more meaningful.

Learners used the concept mapping tool to organize the various layers of information and conceptual integration (Table 2). From learners' assignment submissions it was quite clear that concept mapping using CMapTools helped learners to organize their thoughts in line with the hierarchical layering of the concepts. Student submissions showed organization of geographical concepts in clear hierarchical orders with the breakdown of bigger concepts into sub-concepts that were developed during the earlier courses. While the course in question was AAG232, the integration of concepts from other courses (AAG231) as well as student's own research findings from courses outside geography (marked by students as 'Background Knowledge') occurred (Figure 4). Students were clearly assimilating and integrating related knowledge on the issues consciously. Thus, concept mapping enabled learners to analyze the given issue, look for connected concepts, and consciously integrate and organize the various concepts into hierarchical order to arrive at 'meaning making.'

Table 2

Various modes used by students to organize the learned concepts to arrive at 'meaning making.'

	Number of students who used Nested Nodes	**Number of students who used concepts from other modules**	**Maximum hierarchical level used for concept organization**
Group 1 (n=16)	16 (100%)	16 (100%)	4-6
Group 2 (n=6)	6 (100%)	5 (83%)	4-6

One major outcome of using a Cmap for integration of knowledge and meaning-making came from the integration of field experiences with learned concepts. All learners felt that aspects learned through field work could be well organized and linked with resources and theoretical concepts through the use of Cmaps. Concept maps allowed learners to integrate ideas learned in the classroom as well as observations and measurements made in the field. This helped them develop a holistic understanding of the application of the concepts in the real world. Since Cmaps could be used as repositories of resources and subsequently for connecting them to learned concepts, it offered a very robust platform for developing the knowledge around known and experienced issues both in the field and in the classroom lessons. The learners used the platform to organize many types of resources; some even linked videos taken during the field work to previous class notes and PowerPoint slides. Drawing concept maps was an effective way for learners to express their learning and understanding. The link between field observations and the classroom lessons was a crucial learning process which helped students develop a holistic understanding. More than 80% of learners mentioned that they will use concept mapping for future learning and most said it helped them review learned concepts before exams. This emphasizes the power of Cmaps in the organization of understanding.

However, some resistance to the idea of using concept mapping was observed. The exercise of using concept mapping was imposed on these learners and, in general, the younger learners (Second Year students) responded more positively to the exercise than the Third Year students. This might be because of the seniors' reluctance to use something new as these learners preferred using written notes and more linear PowerPoint slides to Cmaps. Interestingly, while the Second Year students used a Cmap directly to present their findings, the Third Year students resorted to PowerPoint and only linked to Cmaps when required even though the Cmaps had already been developed and submitted by them as class assignments. The Third Year students also resisted the use of linking words between the nodes, keeping them unmentioned. They felt they were not yet ready to express the connecting processes explicitly by themselves even though they were mentioning all the correct processes during the verbal presentations. Some (from both groups) did mention that initially they were perplexed by the 'small box with question marks' and did not know how to use them and found it easier to 'just delete them.' With progressive use, this problem was avoided. However, just as Edwards and Fraser (1983) found out, a number of learners saw this as a lot of extra work which they would happily avoid if possible. They did, however, accept that using a Cmap helped them make the correct links in the concepts.

More learners in their Second Year (75%) saw concept mapping as useful for dynamic knowledge building (50%) and sharing (75%) but both groups agreed that it is good for group work. It was generally agreed that, given adequate time, Cmaps are useful for knowledge building but it has to be preceded by lectures.

In general, learners from both courses seemed to be able to use CmapTools to conduct their research and organize their findings without too much of a problem. Some negative aspects, however, were pointed out.

The most common problem learners had was the difficulty of transferring Cmaps from one computer to another because it delinked most links with the resources that were painstakingly created earlier. This caused some disruption as re-linking takes some time and has to be done one by one. However, this in no way undermines the usefulness of the framework on which CmapTools rests. Complicated and interrelated concepts were effectively presented with all links for both the courses and were useful for the summing up of the entire course for review. Most learners appreciated this summing up exercise through CmapTools and commented that it was useful for exam reviews.

Conclusion

In conclusion, it can be said that CmapTools do have a 'Low Threshold' (Cañas et al., 2004) with learners being able to use it by probing around and using the software's Help Tool. More than 95% of all learners from both groups felt that learning through the Help Menu was useful and that the learning curve was flat which enabled them to concentrate on the actual work. Learners learned that not only can they organize the information and concepts, they can also use creative ways to highlight and map their own views and issues using the software. This was done through self exploration alone. Collaboration was also useful for knowledge development and organization. Concepts could be slowly developed as the group work increased and as the course progressed. Therefore, the 'High Ceiling' is also proven. Some learners also mentioned that the 'Views' window helped them to see all the resources available making it very useful for student controlled learning; this allowed control over the access of learning resources.

For all courses where concepts are intricately linked, as shown in the examples of courses under consideration, a linear delivery of a series of concepts may not provide the optimum outcome of learning and may produce segregated understanding of the concepts. The learning outcomes of earlier foundation courses may also be lost as learners progress from year to year if such prior knowledge is not incorporated consciously into the knowledge concepts in any course. From this respect the courses under study were found to be ideal for incorporating CmapTools-based concept mapping. As Ault (1985) comments, concepts signify patterns in events and connect experiences. This strength of Cmaps makes it useful for integration of geographic concepts. Classroom processes of group presentations and Cmap submissions suggest that using CmapTools to draw up connectivity of several concepts proved to be useful for integrating prior knowledge. CmapTools helped the university learners under study develop and reinforce integrated conceptual knowledge. Also, when student responses were analyzed, it appeared that they were encouraged to use this learning strategy for future ventures into knowledge domains.

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