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USING CMAPTOOLS FOR INTEGRATION OF CONCEPTS AND A HOLISTIC GEOGRAPHIC UNDERSTANDING

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Abstract. The potential and the powerful uses of concept maps as a learning tool is well exhibited in an inter-disciplinary subject like Geography, where integration of progressively developed concepts, incorporation of field experiences and data, and integration of location-specific applications of learned concepts lead to a holistic understanding of otherwise potentially segregated geographic processes. Two undergraduate courses in Physical Geography used CmapTools to integrate various classroom-based and Field-based knowledge in order to develop a meaningful holistic understanding of many concepts, which otherwise fail to bring the much desired connectivity among the many facets of this inter-disciplinary subject domain.

1 Introduction

Geography, as a subject, is interdisciplinary in nature, with facets taken from the various sciences to study the environment on Earth. Many of the geographic processes, therefore, require the learner to integrate multiple concepts for developing a holistic understanding, to develop the much talked about 'Big Picture' about 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, which provide the much required real life relevance to learning. This requirement for an integrated understanding create a niche for a system that provides the learner a platform to park previously learned concepts, direct field experiences, case studies, relevant resources of various nature for reorganizing them in order to create a new concept map which help create an integrated understanding of the issue at hand. Such tasks leading to a dynamic knowledge development are deemed to be possible through the use of CmapTools, a concept mapping tool which was used in two undergraduate Geography courses for this study. The courses chosen were a second year module on Biogeography (AAG232) and a Third Year module on Catchment Management (AAG331). The rationale for choosing these two modules lies in the very character of the two courses. Biogeography is an extremely inter-related discipline, which draws on concepts from disciplines such as Geomorphology, Hydrology, Biology, all covered by students prior to taking this module. Catchment Management is another module which is an application module following the modules on Geomorphology and Hydrology understanding and application of which is essential for examining catchment management issues. Therefore, both these courses were ideal for integrating and mapping of many concepts.

Objective of using the concept mapping technique was to facilitate a holistic understanding of inter-related concepts, incorporating 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 exercise, learners were expected to integrate previously acquired knowledge from earlier/ other related Geography modules, available resources, own research, group fieldwork investigation (surveys, data, observations) to develop concept maps, using CmapTools, with appropriate nodes and linkages, which indicate their ability to integrate concepts for a holistic understanding of the environment, the inter-related processes and links.

2 Background and justification for use of CmapTools

As De Simone et al (1999) point out, college/ university learners are assumed to be proficient readers. However, in line with other findings (Bransford, 1979; Novak and Gowin, 1984; De Simone et al, 1999), it may be reaffirmed that such learners are still not proficient enough to abstract information and formulate a coherent understanding of the inter-related issues as much of the learning may be taking place as separated nodes or bodies of knowledge, without any integration or organization. Modular systems followed in the universities serve to create this artificial division among originally inter-related disciplines and unless conscious efforts are made to integrate these learning objects, the learner goes through the system unobstructed and without comprehending the inter-dependences that naturally exist among these disciplines.

While in the course of the planning and delivery such integration may be incorporated, 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 of 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, as shown in Figure 1.

The pre-requisites are emplaced to ensure that students come with the required prior knowledge to be able to assimilate and organize their prior experiences for a more effective learning in the subsequent courses. However, since the courses are delivered as separate modules, students tend to process information as discrete units, rather than as linked continuum of knowledge, as is intended in the curriculum. This leads to less than optimum learning integration.

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

Geographic learning also requires students to apply their knowledge from more than one discipline to analyse real-life environment. This is instituted in field work which requires students to apply their prior knowledge to carry out investigations and also to analyse the collected data. However, very often the students tend to disregard the connections between previously learnt concepts and dwell in the current course content to process information as discrete unit outcome, rather than as linked ideas. This leads to less than optimum learning as well.

Thus an additional objective of this study was to examine how students can be initiated to incorporate what they have learnt before (in previous modules) to analyse what they observe in the field to answer some focus question, which is aimed at providing a holistic understanding of the issues under study. For the Second year course this was done through the use of Field investigations and field data collection, while for the Third Year course case studies were used to involve students to use and organize their past knowledge. Both the groups were involved in organizing the knowledge through concept maps using CmapTools to draw up the Big Picture and establish the linkages. Fensham et al (1994) mention that conceptual change is often an accretion of information that the learner uses to sort out contexts while Gunstone and Mitchell (1998) proposed that conceptual change is coordinated with the learner recognizing, reconstructing, reviewing and restructuring relevant aspects of their understanding in a way to provide 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 provided a suitable platform to initiate students to learning through concept mapping.

3 Planning and execution of the study

As Novak and Gowin (1984) point out, concept mapping is among the most promising methods for promoting relational conceptual change where students make use of various symbols to determine the relationship between the concepts. Such concept maps have been in use in all facets of education and training to foster learning (Novak and Cañas, 2004). These maps are hierarchical diagrams providing a graphic display of interrelationships among concepts. For the present study the students from the two courses used concept mapping to understand and establish relationships between concepts and demarcated to and fro links to indicate the linkages.

A CmapTools-based learning activities model used by Novak and Cañas (2008) was adapted to suit this present study (Fig.2). It 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) Multi-disciplinary conceptual integration and understanding. At the end of the course, a digital portfolio was created by each student, using the CmapTools.

This scheme adopts Novak & Cañas's (2004) model following Vygotsky's (1978) idea of 'Zone of Proximal Development', with the lecturer providing same opportunities of a higher level of understanding to all students in the class through the common lectures, lab sessions and assignments and providing the direction through generating the focus question, an idea also confirmed to have positive outcomes of learning by Bransford et al (1999).

Justification for using the concept mapping technique lies in the discipline which is more effectively delivered with graphic representations, both for the knowledge structure as well as for the supporting resources that can be organized thematically and hierarchically. Graphs, maps, photographs, other visuals such as videos are common resources used in Geography, 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 which the

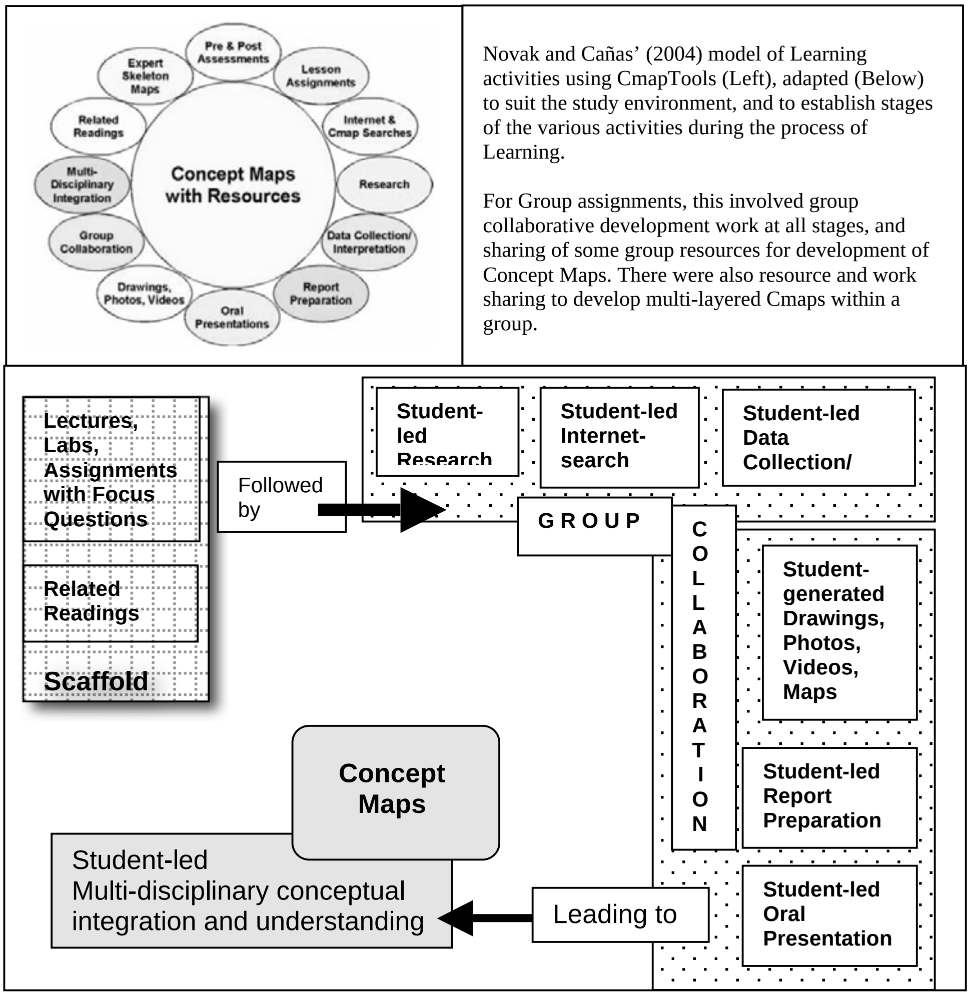

Figure 2. Spectrum of Learning Activities for the study, based on Novak and Cañas' model (2004)

learner needs to assimilate to understand the inter-relationships. The nesting and collapsing of concepts and expansion of such, when required is an aspect of immense usefulness in Geography. This may be referred to as the 'High Ceiling' capability of the tool, as individual concepts can be progressively developed, as the learner goes deeper into the learning environment. Thus while a basic concept map 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 re-develop the concept map as he/ she goes through the course. This aspect was well-used during the present study, with students developing and redeveloping or reorganizing previously learnt concepts (from earlier relevant but other modules) and also incorporating previous knowledge as they went through the course. This framework for assimilation and incorporation of previously learnt concepts to develop new ones is in line with Ausubel's (1963, 1968, and Ausubel et al, 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 learning, based on prior relevant knowledge (with the study courses placed on the pre-requisite foundation courses in previous years). The aspect of providing motivation for learning meaningfully was provided by the requirement in the course to make meaningful integration of classroom learning with direct observation and quantitative data collection in the field around some focus questions and also the need to interpret conditions in the case studies, which reflected no single concept but an amalgamation of multitude concepts, as it appears in the real world. By trying to make sense of these integrated environments, the students were faced with the need to be able to integrate old and newly acquired knowledge, and also to do the own research to build and reorganize available information to suit the requirement of the focus question. Thus the scheme supported meaningful learning, which required (integration of old and newly acquired knowledge, reorganization of all relevant knowledge, representation of acquired information in ways deemed appropriate by the learner (providing the learner control), freedom to initiate new research and new ways of representing findings, all of which gave the much-needed commitment and motivation for 'Meaningful Learning' to take place and provided opportunities for creative products at the end of the course.

4 Organisation of the coursework

Course work for both courses focused on progressive development of knowledge acquisition: 1st phase was to connect present and prior learned concepts to integrate their understanding of the biogeographical and geomorphological processes. The 2nd phase was to integrate these relevant concepts to understand and assess a given real-life environment from field observations and from case studies. Both the groups were given one assignment each, for each phase, as group endeavours, where the students negotiated together in pairs, to revise and reconnect prior knowledge and collectively worked on development of the conceptual models to answer the given focus question. In both cases, students were given the Focus questions and all groups used CmapTools to develop the linked concept maps using the computer. Links were developed after much negotiation. Figure 3 sums up the processes followed throughout the courses to incorporate conventional classroom processes with the student-centred knowledge organization, 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.

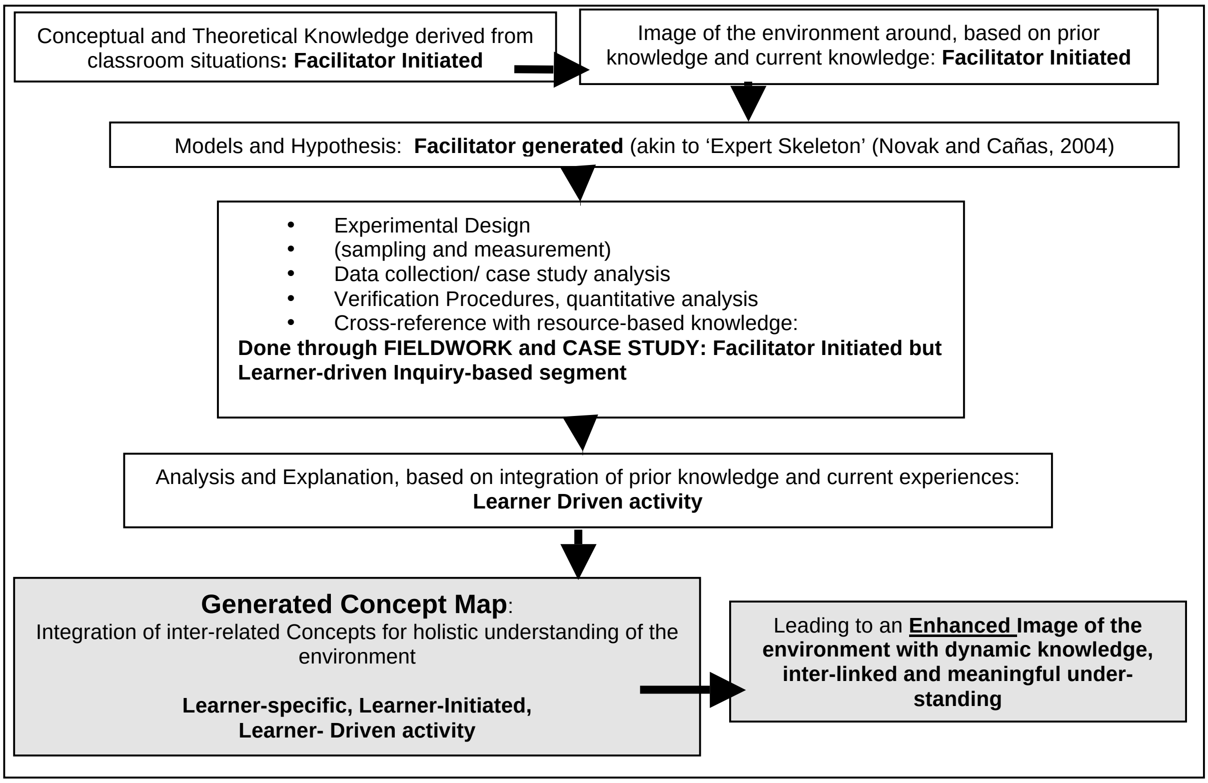

Figure 3 Flow of work during the courses to develop Geographic Understanding by using CmapTools

Assignment 1 for Group 1 was to create ground work to prepare them for the subsequent more in-depth exposure to interconnected concepts, as experienced in the field-based work (Assignment 2). This also provided the link between theoretical concepts and Lab procedures and analysis. For Group 2, Assignment 1 related to assessment of some controlling processes that impact the Catchment environment, in response to developmental activities in the catchment area. This initiated them to find the inter-related nature of the various controlling factors, with each pair concentrating only on one or two processes, but during group presentation in the class the processes operating in the entire catchment were discussed and established, to provide the complete picture (The Big picture) and the linkages. The idea was to illustrate the interdependences of all the processes in the catchment, which, in earlier modules were taught/ learnt separately. The second assignment was on case studies where application of al relevant conceptual understanding was required to interpret the given environment.

In this course design fieldwork and the case studies provided the exposure to help generate the new image of the environment which was reflected through the concept maps. Thus the concept maps were used as a continuum for the development of explicit holistic geographic understanding. The much-required linked-meaning-making between the conceptual understanding and the explicit real-world relevance was expressed using the concept maps. It thus forms a vital link in the knowledge development of the learner. Such an integration of the real world within a cognitive framework enables students to develop an awareness and relevance of Geography and as Burt (1989) emphasizes, helps students 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, to understand and establish the links to create a deeper and self-driven meaning of the given environment through linking relevant learned concepts with the observed, researched, and analysed 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 present study emphasizes knowledge building and meaning making through the use of concept maps in order to create a holistic geographic understanding from a shared fieldwork/ case study experience.

5 Processes and Stages of work

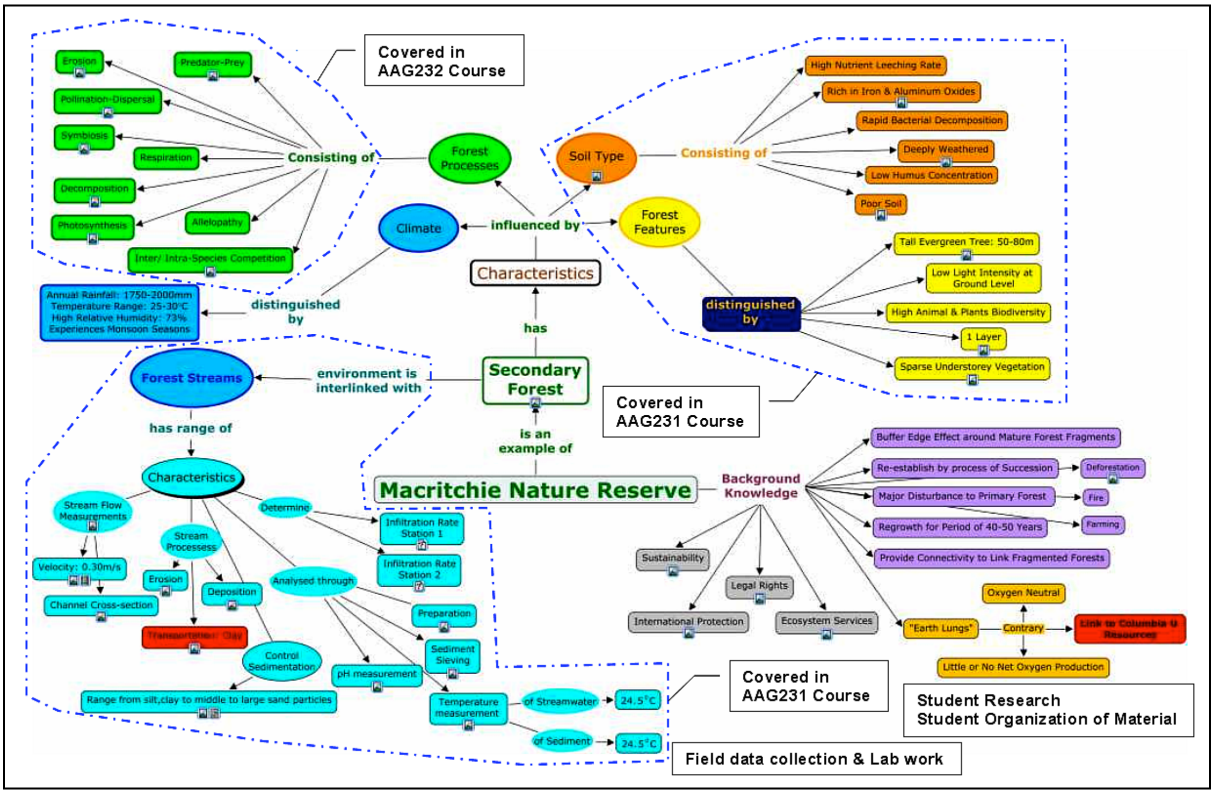

Fig 4 Integration of prior knowledge, fieldwork, course materials, own research using a Cmap drawn by students

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: Biogeographical environment of a Tropical Rainforest (Group 1), Geomorphological and Hydrological Processes in a Catchment Basin undergoing urban development (Group 2). This stage of knowledge development can be parked under the banner of Buttimer's *ERGON: response to a stimulus.* Instructions were also given to draw up concept maps for these courses, using CmapTools, introduced earlier in a previous course, instead of a written assignment. The usefulness of concept maps in subsequent revision work before examinations was also pointed out. Students were given the choice of using as many types of resources as they preferred and were asked to be creative in the 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 discovery of interdependent processes and creation of new artifacts and knowledge, and dynamic meaning making of observed processes in a real-world environment and provided relevance to the concepts previously learnt: termed *Poiesis*.

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

Stage 4: Paidaia or *educating stage* was achieved by both groups through development of Concept Maps (using CmapTools) and by presenting these in the class for discussion. This is where the learners shared their learning experiences, re-negotiated 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. Figure 4 shows one such Cmap drawn by a student group, which shows the integration of prior knowledge, field experiences, course materials and own research for developing the final holistic understanding and assimilation. Clearly, this is an indication of knowledge integration.

Finally, one extra achievement was the sharing of all concept maps for future use and possible re-organisation of information.

6 Analysis of student responses

All students using CmapTools for the courses under study were exposed to concept mapping and the CmapTools software in earlier modules conducted by the author and, therefore, all had some prior knowledge and experience regarding the process of both concept mapping as well as maneuvering within the mapping environment. All students were also exposed to various computer-based learning environments. These ensured two things: the learning curve, for most, was near flat and there was no novelty in the use of the software to cloud the learner’s views on it. Following are some of the salient points that came out from the anonymous student survey conducted after the course was over (Table 1).

The survey reveals that all learners found concept mapping beneficial to their learning and all felt that it was useful to organize their learning as ‘smaller concepts’ could be organized inside ‘bigger concepts’, indicating that the use of hierarchical knowledge organization was useful to them. The multi-layered structure of the various inter-related concepts helped students to arrange information in manageable sizes. All students also felt that aspects learnt in the field work could be well-organized and linked with resources and theoretical concepts through the use of Cmaps. The students used the platform to organize many types of resources, some even linked to videos taken during the field work. More than 80% students mentioned that they will use this concept mapping for future learning and most said it helped them revise learned concepts before exams.

Observations by students	**Group 1**	**Group 2**
Group1 (Second Year students): n=16; Group 2 (Third Year students): n=6; Total n=22		
Prior knowledge and exposure to software and concept mapping	16	6
Easy to use	16	6
Learning the details of the software: **Self-exploration**	16	6
Easy to see the connections in the concepts	16	6
Shows the Big Picture	16	4
Sharing the concept maps helps	12	-
Helps Visual Learners	8	2
Helps Revision before exams	12	4
Links the smaller concepts together under a bigger concept, making understanding easier and more meaningful	16	6
Different resources from field work can be linked to concepts, providing relevance	16	5
Resources added: Photographs	16	6
Resources added: MS Word files	16	6
Resources added: MS Excel files	16	6
Resources added: PDF files	12	6
Resources added: Websites	16	6
Resources added: PPT slides	8	6
Resources added: annotations and comments	12	6
Resources added: animations/ video clips	8	2
Will use for future learning	14	4
Cooperative knowledge building through group work	12	4

Observations by students	Group 1	Group 2
Can be dynamically enhanced	8	-
Promotes creativity	6	-
Free to use	4	-
Supports Student-centred Learning	12	4
Links are lost when moved from PC to PC	16	6
When nested nodes are opened, the whole picture looks messy	1	1
Prefer writing on paper than on PC	2	1
Very time consuming to develop and create the links	1	2
Prefer learning from texts	1	1
Prefer materials in PPT format/ Lecture notes	1	1
May not suit learning styles of all	2	2
Prefer using other learning techniques (did not specify)	1	1

Table 1: Student Views on the use of CmapTools and Concept Mapping as a learning tool

However, some resistance to the idea of using concept mapping was observed. The exercise of using concept mapping was imposed on these students and, in general, the younger students (Second Years) responded more positively to the exercise than the Third years. This might be because of the Seniors' reluctance to use something new, as these are the students who preferred using written notes and PPT slides to Cmaps. Interestingly, while the Second Years used Cmap directly to present their findings, the Third Years resorted to PowerPoint, only linking to Cmaps when required, although the Cmaps were already developed by them and submitted as class assignments. The third years also resisted the use of the linking words between the nodes, keeping them unmentioned. It is felt that they were not yet ready by themselves to express the connecting processes explicitly, although during verbal presentations they were mentioning all the correct processes. 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 so 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 students saw this as a lot of extra work, which they would happily avoid, if possible, although they did accept that using Cmap helped them to make the correct links in the concepts.

More students from 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, concept maps are useful for knowledge building, but it has to be preceded by lectures. In general, students from both the courses seemed to be able to use CmapTools to conduct their research and organize their findings, without much problem. But some negative aspects were pointed out.

The most common problem students had was the difficulty of transferring Cmaps from one PC to another which delinked most links with the resources that were created painstakingly 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 inter-related concepts were effectively presented with all links for both the courses and were useful for the summing up of the entire course for revision. Most students appreciated this summing up exercise through CmapTools and commented that it was useful for exam revision.

7 Conclusion

In conclusion, it can be said that CmapTools does have a 'Low Threshold' (Cañas et al, 2004), and students are able to use it by probing around and using the Help Tool of the software. Students learnt that not only can they organize the information and concepts but they can also use creative ways to highlight and map their own views and issues, using the software and this was done through self-exploration alone. Collaboration was also useful for the knowledge development and organization and concepts could be slowly developed as the group work increased and the as the course progressed. Therefore, the 'High Ceiling' is also proven. Some students also mentioned that the 'Views' window helps to see all the resources available, making it very useful for student-controlled learning, allowing control over the access of learning resources.

For courses where concepts are intricately linked, 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 students 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 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 and to develop and reinforce integrated conceptual knowledge among the university students under study, and from the student responses, it appeared that the learners were encouraged to use this learning strategy for future ventures into knowledge domains.

8 Summary

Students in two Undergraduate courses in Geography used CmapTools to progressively integrate relevant prior knowledge, knowledge derived during lecturer-generated sessions and incorporated their own experiences during field-based research. This helped them to develop a holistic understanding of the many inter-related processes operating in the complex real-world geographic environment**.**

References

Ault, C. R. (1985). Concept Mapping as a Study Strategy in Earth Science, Journal of College Science Teaching, Sept-Oct, 38-44.

Ausubel, D. P. (1963). The Psychology of meaningful verbal learning, New York: Grune and Stratton.

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

Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). Educational Psychology: A Cognitive View (2nd Edition). New York: Holt, Rinchart and Winston.

Bransford, J. D. (1979). Enhancing Thinking and Learning. New York: W.H. Freeman.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds) (1999). How people Learn: Brain, mind, experience, and school. Washington, D.C.: National Academy Press.

Burt, T. (1989). Science and Fieldwork in Physical Geography, Teaching Geography, October, 1989.

Buttimer, A. (1993). Geography and the Human Spirit, The Johns Hopkins University, Baltimore and London.

Cañas, A. J., Hill, G., Carff, R., Suri, N., Lott, J., Gomez, et al (2004). CmapTools: A Knowledge Modeling and Sharing Environment, in Concept Maps: Theory, Methodology , Technology, Proc. of the First Int. Conference on Concept Mapping, Eds. A. J. Cañas, J. D. Novak, F. M. Gonzalez, Pamplona, Spain 2004.

Cañas, A. J., and Novak, J. (2006). Re-examining the Foundations for Effective Use of Concept Maps in Concept Maps: Theory, Methodology, Technology, Proc. of the 2nd Int. Conference on Concept Mapping, Eds. A. J. Cañas, J. D. Novak, San Jose, Costa Rica, 2006.

Czuchry, M., & Dansereau, D. (1996). Node-link Mapping as an alternative to traditional writing, *Teaching of Psychology*, *23*(2), 91-96.

De Simone, C., Oka, E. R., Tischer, S. (1999). Making Connections Efficiently: A Comparison of Two Approaches Used by College Students to Construct Networks, Contemp. Educ. Psychology, 24, 55-69.

Edwards, J., & Fraser, K. (1983) Concept Maps as Reflectors of Conceptual Understanding, Research in Science Education, 81(2), 193-215.

Fensham, P., Gunstone, R., & White, R. (Eds). (1994). The content of science: A constructivist approach to its teaching and learning. London: The Falmer Press.

Gunstone, R. & Mitchell, I. (1998). Metacognition and conceptual change. In J.J. Mintzes, J.H. Wandersee, & J.D. Novak (Eds) Teaching Science for understanding: A Human constructivist view (pp 133-163). San Diego, CA: Academic Press.

Liu, X. (2004). Using concept mapping for assessing and promoting relational conceptual change in science, Science Education, 88 (3), 373-396.

Novak, J. D. & Gowin, D. B. (1984). Learning How to Learn. New York: Cambridge University Press.

Novak, J. D. & Cañas, A. J. (2004). Building on New Constructivist Ideas and CmapTools to Create a New Model for Education, in Concept Maps: Theory, Methodology, Technology, Proc. of the First Int. Conference on Concept Mapping, Eds. A. J. Cañas, J. D. Novak, F. M. Gonzalez, Pamplona, Spain 2004.

Novak, J. D., & Cañas, A. J. (2008). The Theory Underlying Concept Maps and How to Construct and Use Them, Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Institute for Human and Machine Cognition. Retrieved on 22.4.2008 from http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf

Vallega, A. (2000). Representing Spatial Complex Systems: Geographic Education Facing Post-modern Society in R. Gerber and Goh K.C. (eds), Fieldwork in Geography, Reflections, Perspectives, and Actions, Kluwer Academic Publishers, 235-261.

Vygotsky, L. (1978). Minds in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.