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## SOME IDEAS ABOUT CONCEPTS

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### Abstract

The intention behind this workshop is to summarise some of the research about the use of concept maps, concept circles, Gowin's Vee and similar metacognitive devices that enable outsiders to find out the individual's own understanding of particular concepts and the way in which these concepts are interlinked. There is research evidence to suggest that time spent on teaching students to use concept maps is well spent, as it does clarify concepts for some students and will enhance their academic performance. The author is unaware of research evidence linking the other metacognitive devices mentioned with improved performance, but this seems a reasonably plausible expectation.

### Introduction

I was reminded of 'concepts' yet again when watching a video at home and it was introduced with the words 'this video contains 'adult concepts' and occasional scenes of violence' or some such words. I could not help wondering what 'adult concepts' were and whether or not it was a good thing to try to teach them to children or indeed was it possible to teach them to children? [OHP#1].

The problem with the word 'concept' is that it tends to have different meanings in different contexts with different authors and I suspect that this meaning is also changing with time. As a standard procedure I will check with Turner (1987) [OHP#2 and Bullock and Stallybrass (1977) [OHP#3].

Looking at the use of the word 'concept' Tisher, Power and Endean (1972) are helpful, in that they give a variety of usages by different writers who state that a concept is:

- *the way an individual organises and derives meaning from his experiences.*
- *a synthesis of events experienced and of the conclusions drawn about these experiences.*
- *a mental image which helps an individual classify his experiences ( as such, a concept is something which continually changes as experiences accumulate).*
- *a generalisation or abstraction ( in the mind ) which is used to represent a group of things.*

About twenty years ago, when I was involved in a research project, with a group of colleagues, on the Gagne (1965) hierarchy of educational objectives, it was the last of these definitions that was uppermost in our minds, with the emphasis being on the idea that to understand any particular area of science everyone would have to go through the same sequence of thought. In the case of the Gagne hierarchy this was from facts (multiple discriminations) to concepts, to principles, to problem solving, which was the highest level. It was assumed that there was a best

logical way to do this and most people would have to work this way in the end. Gagne's definition of concept learning was:

- *The learner acquires the capacity of making a common response to a class of stimuli that may differ from each other widely in physical appearance. He is able to make a response that identifies an entire class of objects or events.*

Gagne, 1965, 58.

Palmer, 1970 [OHP#4] illustrates the way in which the learning structure of our experiment was constructed independent of the individuals taking part. It shows how the content of forty objective questions on 'structure bonding and properties', which had been taught to 450 students by screening three one hour movies specifically made for the purpose, were interlinked at various levels of the Gagne hierarchy. For example Question 1 was a multiple discrimination (fact) question about the periodic table which was linked to a concept learning question (number 36) about the periodic table, but the fact from Q 1 plus the fact from Q 21 would be needed to understand the concept in Q 36. Similarly this concept was linked to the concept in Q 18, and both concepts would need to be understood before being able to comprehend the principle in Q 33. And so on, to the problem solving area where two principles need to be understood to solve the problem that utilizes these principles. In theory questions at the lower levels had to be answered correctly, if the right answer was given to a higher level question. That is, theoretically the Gagne taxonomy should be both hierarchical and cumulative, though the cumulative nature of the hierarchy was not proven in our experiments.

It should also be pointed that there were other taxonomies which had similar features (Bloom et al,1956). Also a number of other researchers wrestled with the problem of concepts using various methodologies with Gower et al, 1977 [OHP#5], being one of the later workers utilising a fixed set of minor concepts universally underlying some major concept, in this case, the mole. . Concepts were still used hierarchically, for example with Comber's 1983 analysis of then current Nuffield syllabi. By coincidence on the very next page in the School Science Review ,an article by Moorfoot, 1983 finds out children's own physics concepts by interview, which is an early paper using 'constructivist' methods: this was very much a time of change with new methods coming to the fore. This was the time that the 'constructivist' movement was starting, with researchers taking the ideas of Ausubel, 1968 more seriously than his contemporaries had done. For a brief explanation of these ideas see McClelland, 1982 and Summers, 1982. The main ideas that were taken aboard were the ideas of 'meaningful learning' and his dictum 'ascertain what the learner already knows and teach accordingly'. The work of many researchers in different countries has investigated the area of children's prior knowledge of aspects of science; amongst those in the field are Anderson (Sweden), Driver (UK), Novak (USA) and Osborne (NZ) and this general area of study is one which excites considerable interest and is currently popular amongst science education researchers. From this wider constructivist theory varying groups such as those mentioned previously (Driver, Children's Learning In Science, CLIS, and Osborne, Learning In Science Project, LISP) group have emerged each concentrating on particular aspects of the development of scientific concepts amongst individuals. The most widely disseminated work is about children's ideas in science (children's misconceptions of science, or alternative conceptions in science), and the CLIS and LISP projects have produced a considerable literature. However the projects have moved on from an emphasis on children's preconceptions and are considering the various ways that children can become more responsible for their own learning. In the United Kingdom CLIS courses emphasise the following points:

- 1 *Acknowledgment of the learner's prior ideas.*
- 2 *Practical ideas which relate to and extend student's knowledge.*

- 3 *Opportunities for thinking.*
- 4 *Emphasis on collaborative learning methods.*
- 5 *Using intervention strategies to encourage students to reshape their thinking.*
- 6 *Learning how to learn.*
- 7 *Establishing a supportive classroom environment.*

*(Brook, Driver and Johnston, 1989)*

The above points really need considerable amplification, but they provide the basic ideas of the ways in which teacher with a constructivist view will be moving. In Australia too, both teachers and researchers have been working out what a constructivist view of science education means for them.

The initial model used by staff at Monash University was the POE model (predict, observe, explain) which was used to probe first year physics students in 1980 (Gunstone and White,1981).

*A striking feature of the investigation was the poor quality of the explanations that the students offered.....Clearly they had learned to pass examinations, but had not learned to understand physics.*

*(White, 1988)*

Baird (1990) explains his views on metacognition. He completed a Ph.D at Monash University on that topic in 1984 (Baird, 1984) using an action research methodology as a result of his conviction that most school students had only a limited understanding of what they were doing and very few could explain why they were doing it. Researchers at Monash and staff at Laverton High School in combination with John Baird and Ian Mitchell started what is now known as the PEEL Project (Project for Enhancing Effective Learning) (Baird and Mitchell, 1988). This has been and still is a very successful project that aims to encourage students at participating schools to be more responsible for their own learning. The project is of particular interest in that it involves all subjects across the curriculum, and that many methods are used in encouraging student participation and interest. It is the wide variety of methods used in enhancing metacognition (clarifying concepts for individuals) that will be the subject of the remainder of this paper.

## **Concept Maps**

At its simplest level a concept map is simply groups of related concepts linked by lines which indicate the way in which the concepts are linked. These maps (as they are then called) are meant to represent the ways in which the individual sees the concepts related in his/her mind. The map on paper should then actually represent the linkage of concepts in the individual's mind. Thus, if we ask the students to draw a concept map of a scientific concept, we should be able to understand how the student is thinking and what their errors are. Let's look at a specific example such as:

1. Photosynthesis. [OHP#6] [OHP#7] (Gunstone and Mitchell).
2. Matter. [OHP #8] (Ross, 1988).

3. Change of State [OHP#9] [OHP #10A] [10B] (Examples taken from student's teacher's work).

Now let us look at a typical set of instructions for making concept maps:

### **One way of having students produce a concept map**

Select a number of interrelated concepts relevant to the topic for which you are interested in students' views, but practise first on a topic with which they are all very familiar. Either as practice or as the main task students can follow these instructions.

*Write each concept on a separate small piece of paper. (This allows the concepts to be moved around by the students as they think about the task.)*

*Put to one side any concept about which the students feel that they know nothing.*

*Arrange the pieces of paper so as to show the way the student sees the relationships between the concepts. When they are satisfied with their arrangement, either stick the pieces of paper down or write the arrangement on a single sheet of paper.*

*Draw lines between any pair of concepts which they see to be related, and write on the lines what they see the relationship to be.*

(Gunstone and Mitchell, 1988)

It is, in fact, easiest to use self adhesive address labels, as the means of constructing the map. The concept maps may be examined by the teacher at his/her leisure and the students may be counseled individually about obvious misconceptions that they may have. Alternatively, the maps may be scored by systems used by Cronin, Dekkers and Dunn,1982 or Stuart,1985 or the combination of systems used by Williamson, 1987 [OHP#10C]. The question is whether the scoring of concept maps is a useful activity: Stuart, 1985 had some doubts about the use of aggregate scoring systems, whereas Williamson,1987 was more positive about his modified scoring techniques:

*Given the significant positive correlation found between some of the component scores and the student's exam and practical work assessments, then it would be appropriate to further research concept maps as predictors of academic performance and/or as alternative assessment tools.*

Similarly a student at Laverton High School, Linda Dibley (1988) wrote from a learner's perspective gave a general view :

*Now, at the end of the year most of us realise that PEEL has helped and has changed the way we learn and has changed it for the better.*

Furthermore she states specifically about concept maps:

*Concept maps were first used in science as a means of linking terms logically together. There didn't seem to be much sense in this at first, but as we began writing how or why certain terms were linked together, concept maps became a major means of focusing our understanding. Therefore they became a useful factor in revision and were seen as a useful part of PEEL by the majority of us - probably one of the few things that achieved such a high level of acceptability.*

I will also quote the views of two teachers and a student teacher on concept mapping:

*I still think that using concept maps to clarify the purposes of class activities has considerable potential. I just didn't give the students enough training in how to construct the maps.*  
(Mitchell, I. 1988)

*.....these maps were very successful for several reasons. They forced students to think about topics, they were useful for assessment and provided useful feedback for both the student and the teacher.* (Dunne, 1988, student teacher)

*We were introduced to the value of concept maps and after we had tried them most of us agreed that they were extremely valuable.....Some of the so-called average students produced excellent maps.* (Mitchell, J, 1988)

The case for concept maps may or may not be considered proven, but it is a fact that the new VCE requirements will need students to provide a concept map on a topic within the first area of study in Year 11, which will be on the topic of 'useful materials' (Healy,1990). To my knowledge it is the first science syllabus in the world to include concept mapping and marks a departure from the norm in that it is indicating that a particular methodology of teaching should be used.

### **Other Metocognitive Devices**

The method of clarifying one's ideas called Gowin's Vee is increasingly popular in the USA. Novak, 1990 makes large claims for using Gowin's Vee on its own or in combination with concept maps, both in the laboratory and in the classroom. He claims and quotes the research that documents considerable gains for disadvantaged students and slow learners. Doctoral research by Gurley is quoted (Novak, 1990) in which students praise the Vee diagram. For example:

*Veas are good.....The Vee makes you think more .And the lab questions are just 'yes/no, draw a picture'.*

[OHP#11A] (Novak 1988),[OHP#11B] (Novak, 1981) and [OHP11C] (Novak , 1990) show examples of the use of Gowin's Vee. [OHP #12] (Mehl and Volmink, 1983) and [OHP#13] (Wandersee, 1987) show a concept map and Gowin's Vee on the same mathematical subject matter and on biology/physics subject matter respectively.

Wandersee,1987 shows a new and different way of linking concepts which he calls concept circles. [OHP#14A] ,[OHP#14B] ,[OHP#14C] and [OHP#15 A], [OHP#15B] give an idea of this method which is closely related to the ideas of the Venn diagram.Wandersee claims that this is one of the easiest of the metacognitive procedures and therefore a good activity on which to start children.

There are a wide variety of other metacognitive methods although those already mentioned are probably the most frequently used in practice. Additional methods are:

Brainstorming: (Nussbaum and Novick, 1981) (Williams, undated) (Bragg and Maher,1986).

Spider Diagrams: (Wood, 1981), (Hackling, 1982).

Burr Diagrams: (Hackling, 1982, p19), (Ross, 1988, p18).

Discrepant Events: (Fensham, 1988).

## **Conclusion**

The above are some of the ways in which the conceptual understanding of our pupils may be improved. Here is one last story as an example. Alan Ward writes extensively about elementary science. One of his articles is on the concept of energy (Ward, 1983) and he writes:

*.....and they contribute towards an insight into the ultimate abstract concept of energy - with all its fundamental mysteries (for in the end nobody knows what energy is).*

To state the obvious, if scientists don't really know what energy is, no amount of metacognitive devices that will fully clarify the concept of energy. So, although metacognition may allow a partial escape from the logic of science, in the last resort scientific concepts have the final say.

## Reference Notes

A list of OHP slides used in the presentation is appended below:

[OHP#1] Cartoon - Ashleigh Brilliant 1981 Appreciate Me Now and Avoid the Rush, Woodbridge Press, California, USA, p111.

TODAY'S CHILDREN ARE REQUIRED TO LEARN WHAT MOST PEOPLE IN FORMER TIMES WERE FORBIDDEN TO KNOW. (IN NEW WAYS?)

[OHP#2] A dictionary definition of a concept - Turner, G.W. 1987 The Australian Concise Oxford Dictionary, OUP, Melbourne.

[OHP#3] A further definition of a concept - Bullock, A. and Stallybrass, O. 1977 The Fontana Dictionary of Modern Thought, Fontana/Collins, London, UK.

[OHP#4] A diagram showing interconnections between questions of similar content areas at different levels in the Gagne hierarchy in a post-test - Palmer, W.P. 1970 A Validation Study of the Gagne Taxonomy of Learning Processes with Reference to Retention, M. Sc. Dissertation, University of East Anglia, UK, p43.

[OHP#5] A diagram of concept hierarchies - Gower, D.M., Daniels, D.L. and Lloyd, G. 1977 Hierarchies among the Concepts which Underlie the Mole, School Science Review, Vol 59, No 207, December, pp285.

[OHP#6] Ways of having students produce a concept map (p6) and Figure 5 (p8) Gunstone, R.F. and Mitchell, I.J. 1988 Two Teaching Strategies for Considering Children's Science, What Research Says to the Science Teacher, ICASE Year Book No 2, ICASE.

[OHP#7] Figures 1 to 5 (p7) Gunstone, R.F. and Mitchell, I.J. 1988 Two Teaching Strategies for Considering Children's Science, What Research Says to the Science Teacher, ICASE Year Book No 2, ICASE.

[OHP#8] Two concept maps illustrating children's concepts of 'matter', Ross, K. et al 1988 Can Children Learn Science? College of St Paul and St Mary, Cheltenham, UK.

[OHP#9] [OHP#10A] [OHP# 10B] (Examples illustrating 'change of state' taken from student's teacher's work)

[OHP# 10C] A scoring system for concept maps. Williamson, S.M. 1987 Conceptual Development in Science Practical Work, M.Ed Thesis, University of Melbourne.

N.B. An alternative scoring system with a more accessible reference is: Gibson, J. 1991 Concept Mapping - An Assessment Tool, The Australian Science Teachers Journal, Vol 37(4), pp72-75.

[OHP#11A], [OHP#11B] and [OHP#11C] All these overheads illustrated different examples of Gowin's Vee Heuristic. References are indicated in the text.

[OHP #12] (Mehl and Volmink, 1983) shows an example of Gowin's Vee Heuristic and a concept map both illustrating the same mathematical problem on the same overhead transparency.

[OHP#13] (Wandersee, 1987) show a concept map and Gowin's Vee together on biological/physics subject matter respectively.



[OHP#14A], [OHP#14B], [OHP#14C], [OHP#15 A] and [OHP#15B].

Wandersee, J.H. 1987 show a new and different way of linking concepts called concept circles, similar to a Venn diagram/Euler's circles.

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