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Taber, K. S. (1994) Student reaction on being introduced to concept mapping, *Physics Education*, 29 (5), pp.276-281.

Student reaction on being introduced to concept mapping

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Abstract:

A small group of students commencing an A level revision course in Physics were asked to draw a concept map for "energy". At the end of the lesson they were asked to comment briefly about their reactions to the task. The student comments were generally very positive, and related to both their feelings about the work they had carried out, and their thoughts about their own learning. It is suggested that these are important aspects of the student learning experience that are too easily ignored by science teachers.

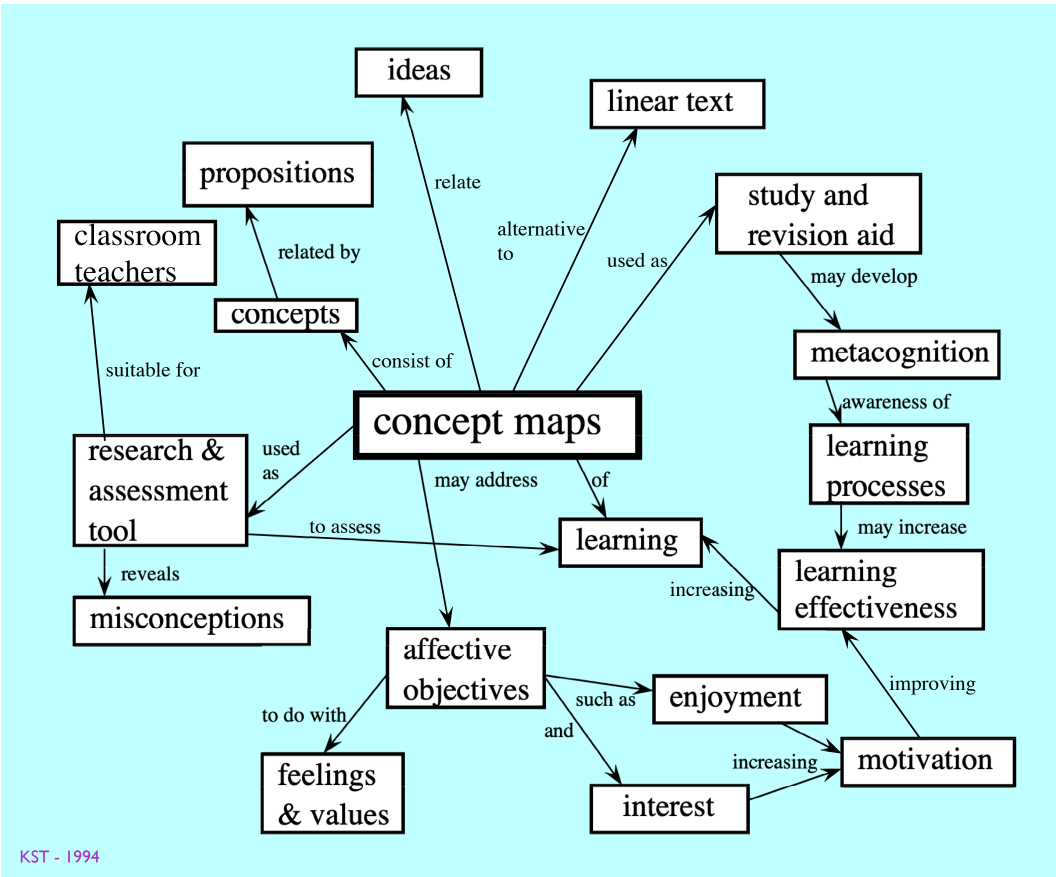

Figure 1. A concept map of some of the themes of this article

What are concept maps?

> "A concept map aims to show how someone sees the relations between things, ideas or people."
>
> White & Gunstone, 1992, p.15

The concept map is an alternative way of representing knowledge. In written text, such as this article, information is presented in a linear manner. Although the reader may choose to read the paragraphs in any order, the material is structured in a particular sequence. Key words may be emphasised in a variety of ways, such as italics, bold type, or underlining. In a concept map material is organised differently: the key words, representing the concepts of the topic, appear highlighted in boxes at the nodes of the map. The relationships between the concepts are represented by connecting lines. Each line stands for a proposition relating two concepts. Unlike a linear text there is no single intended order for 'reading' the map: it is a network of ideas that may be sequenced in many permutations. As an example of a concept map Figure 1 presents the main themes of this article.

What are concept maps used for?

The technique of concept mapping has been much discussed in the literature, both as a learning tool and an assessment technique (Al-Kunifed & Wandersee, 1990), for as Watts has commented in this journal "using concept maps in a lesson can be both diagnostic and instructional" (1988, p.77). The importance of elucidating the existing extent of student knowledge, and any key misconceptions present, before teaching a new topic has been emphasised by those science educators known as 'constructivists' (e.g., see Watts and Pope (1989) in this journal). Whilst some techniques used to explore student understanding by professional science education researchers require time and other resources not available to most practising teachers, concept mapping "offers a technique for revealing cognitive structure which appears manageable within present classroom constraints" (Edwards & Fraser, 1983).

The students, and the task

This paper considers the first exposure to concept mapping for a class of students starting a course in September 1993. These students had just enrolled on a one-year revision course in A level physics. All had taken the subject before, and of the 13 in the group 7 already had pass grades (mostly at D and E, but also a C and even one B grade), 5 had an N, and one had been been unclassified (U). Their first physics class of the session was scheduled from 3 p.m. to 5 p.m. on a Friday afternoon - not an ideal time. Part of the first hour was spent on distributing textbooks and copies of the syllabus. As the students had been fairly passive at the beginning of the session I wanted them to be (mentally) active for the second hour. The concept map would give me (as a 'good constructivist') some indication of what these students knew before I started teaching them. It was also a task that I felt all the group should be able to carry out and feel positive about - an important consideration as these were all students who to some extent were considered 'failures' at A level - even if in some cases this was only because they were aiming for degree courses such as medicine which required very high grades. After several months away from study it seemed a 'gentle', but useful, reintroduction to physics.

Usually in concept mapping the propositions connecting concepts are written on the map in note form (see figure 1). The present author - working mainly with A level students - prefers a slightly different format, with the connections represented by numbered lines on the map itself, and the (numbered) propositions listed separately. One practical reason for this preference is that the maps of advanced students may become so dense with concepts and connections that including the propositions becomes difficult. It is also considered important that students at this level should try and explain the connections in full sentences, as this allows the teacher to diagnose misconceptions that may not be uncovered if - potentially ambiguous - abbreviated labels are used on the map itself. The propositions may be 'marked' for the accuracy of the physics and returned to the student for correction. The map itself may be evaluated in a more holistic manner, considering the range of concepts included and the degree of interconnection of ideas. In one exercise the teacher has a measure of both the sophistication and precision of the students' knowledge of a topic.

As the technique of concept mapping may be novel to many learners it needs to be explained through a familiar concept area before they are able to map out their own ideas. For example, with the group of students discussed, the technique was introduced by the lecturer writing the word 'blood' at the centre of the board and going around the group asking each student to suggest a connected concept. The map was drawn on the board, and the most appropriate wording for each connecting proposition was considered. Examples of the propositions suggested were blood is red, blood contains cells, blood is a tissue, blood contains plasma, there are two main categories of blood cell, some blood cells are red, blood is a fluid, plasma is a fluid. The concept 'blood' was thus linked to - amongst others - the concepts 'red', 'cell', 'tissue', 'plasma' and 'fluid'. After a short tea break the students returned to prepare their own individual maps for 'energy'. The students were asked to work on their own for this task. One of the maps produced has been redrawn as figure 2, and some of the propositions from the different maps are discussed below.

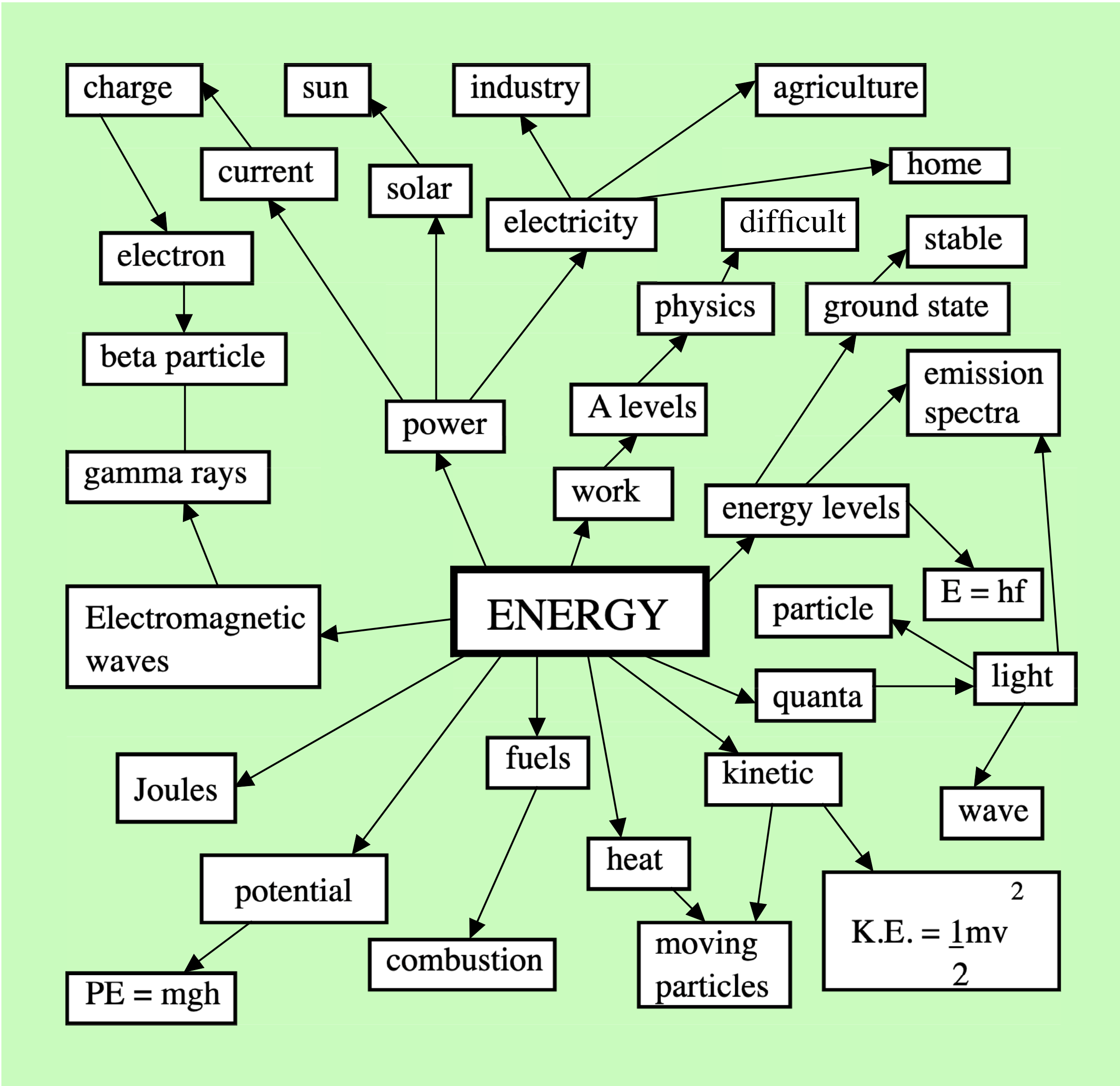

Figure 2. One of the students' concepts map (redrawn)

Misconceptions about Energy

The topic of energy was chosen as one which is central to physics, and which has been shown to be a fertile source of misconceptions and alternative frameworks. For example Watts (1983) has described a range of common alternative frameworks for understanding energy amongst school pupils, and Taber (1989a) has suggested that the many synonymous terms used in texts to refer to the different forms of energy can be a source of confusion. Joan Solomon (1992) has written a useful book about the complex nature of formal and informal (i.e., out of class) learning about the energy topic, and a recent article in this journal (Goldring & Osborne, 1994) has shown that at the start of a sixth form course key concepts of energy are often not understood.

The maps produced by this small group of students did indeed indicate limited understanding of the scientific meaning of energy and related concepts. For example:

> "current is the energy stored in a capacitor"
>
> "electrical energy is charge"
>
> "kinetic - energy which is increasing as an object is moving"
>
> "voltage is velocity of current through conductor"
>
> "insulators have very few electrons"
>
> "kinetic energy is a form of energy an object has due to its position", and
>
> "some chemicals when combusted give out energy in the form of heat due to the breaking of bonds"

The reference to electrical concepts shows how concept mapping may allow students to make connections between different syllabus topics. In addition one map used a non-standard term - of the type that has been labelled 'inappropriate' (Taber, 1989, p.61) - for a form of energy,

> "fuel energy - petrol, diesel, coal etc. all provide fuel energy"

It may be worth reiterating that all the students in the group had previously completed an A level course in physics, and about half had already passed the examination. The value of the technique as a means of diagnosing the extent of student understanding - and their misunderstandings - may be appreciated from these examples.

The affective domain: the importance of attitudes and values in science education

A well known tool for assessing the demands made by course materials and tests is Bloom's 'taxonomy of educational objectives in the cognitive domain'. By the cognitive domain Bloom and co-workers meant the intellectual skills such as comprehension and analysis that are required for conceptual development. What is sometimes forgotten is that Bloom and his colleagues also considered how education aims to develop certain attitudes and values, as well as knowledge; and they produced a taxonomy for this 'affective domain' (Krathwohl, Bloom & Masia, 1964). Few teachers would doubt that feelings and values are important as well as understanding. Science teachers are interested in developing certain attitudes towards science, as well as increasing knowledge. We want our students to enjoy physics, and to see that it can have a role in improving the quality of life. In my own experience I know how easy it is to forget such aims when trying to 'get through' an A level syllabus in the time allowed. Although we all wish to transmit our interest and enthusiasm for science, what do we actively do to ensure out students develop the attitudes we would hope they might acquire?

A few years ago I undertook some classroom observation to study the teacher-pupil interaction in a secondary school. In particular I was interested in whether there were differences between the interaction experienced by girls and boys in science classes, and especially in physics lessons. My starting point was an observation schedule used in the GiST (Girls into Science and Technology) project (Ward, 1986). Although this had categories for how interaction was initiated, it did not take account of the context of classroom interaction. I soon discovered (or rather became explicitly aware - it is surely part of all teachers' tacit professional knowledge) that a considerable proportion of the teacher-class interaction involved administration, or control and discipline, rather than the formal curricular content of the lesson. In addition with some teachers there was a certain amount of interaction that appeared to be purely social in nature, although it was not possible to say to what extent this was a deliberate technique to improve the classroom atmosphere. In my own study I developed a two dimensional recording schedule to allow both for initiation and context of interaction (Taber, 1992). While I was developing my methodology I undertook an 'unstructured' observation (i.e., taking descriptive notes, rather than using a coding schedule) of the Head of Physics teaching a GCSE physics class. I was interested to see how she involved some of the girls in the group who seemed to have limited interest and little confidence in the subject. Rather than asking them difficult conceptual questions that may have been perceived as threatening and could have been damaging to pupil self-esteem, she instead asked them about their feelings for the topic being studied (electromagnetism.) Of course these were questions they could answer, and this approach allowed them to take part in the lesson in a 'safe' manner. I decided that my category of interactions related to lesson content should be split into cognitive and affective sub-categories. There were a number of research questions that came to mind: did all teachers ask these sorts of questions? Were such questions restricted to certain groups, or used with all pupils?

Was it mostly the weaker pupils to whom they were addressed? Were such questions predominantly directed to one gender? In fact I never got to answer most of these questions. Although during thirty science lessons observed using the schedule there were 679 interactions in the two 'content' categories (compared with 89 social, 248 discipline and 352 administrative interactions) - only 17 (2.5%) of these were classed as 'affective' rather than 'cognitive'. It was the only one of the five context categories where girls were involved in more interactions than boys - but the number of 'affective' interactions was much too small to draw any conclusions from this (Taber, 1989b.) In this case study then very few explicit references were made to how the pupils felt about science, rather than what they knew.

The A level revision students referred to above had about three-quarters of an hour to prepare their concept maps. At the end of this time I asked them to note their reactions to the task: was it fun, was it difficult, did it make them think? My own perception was that they had worked quietly and quite intensely, and most showed no sign of running out of ideas.

One student thought the exercise "not fun but necessary", but others disagreed as may be seen from their comments:

> "fun"
>
> "I quite enjoyed doing it"
>
> "I think this is a very pleasant experience"
>
> "it was interesting"
>
> "very interesting"

Metacognition: learning to be an effective student

The term metacognition is used to refer to the extent to which learners are aware of, and understand, their own learning processes. It is suggested that students lacking metacognitive skills may expect to learn simply by attending classes, making notes (often verbatim records) and passively reading their text books. Those with more metacognitive sophistication realise the need for their learning to involve active processing of material through such activities as restructuring their notes, tackling problems, and abstracting texts. Such students are able to assess their own learning, and to make informed decisions about the activities and syllabus topics they most need to focus on. One common attitude amongst students commencing an A level course is to see individual pieces of work as unrelated, and to consider an assignment 'finished' once it has been marked and returned by the lecturer. The concept map - which does not have a beginning or end - is an ideal vehicle for encouraging a different view: that students' work is subject to review and development. This is particularly true when the map and propositions are presented separately as the lecturer may correct the list of propositions in detail, but avoid (physically) marking the map itself. The map may be assessed at a particular time, but seen as an on-going assignment subject to further development.

At the College where I teach a large proportion of our A level students move on to higher education. They often come to us from GCSE courses where they have been "spoon-fed" by their teachers, and leave us to go to University where they will usually be expected to be self-organised independent learners. Part of the role of the teacher of 16-19 year old students is to help them develop into effective independent scholars. An important part of this is learning to reflect on the learning process itself, and to assess one's own learning. Consider the following comments made by these students on undertaking the energy concept map:

> "Made me remember the connection between physics terms"
>
> "at first it was easy, but got hard later. My knowledge of physics is very un-organised at present"
>
> "Found it slightly difficult, don't remember most of the things, had to think a lot"
>
> "I feel a little disappointed that I can't remember that much more to put on"
>
> "I didn't think I'd be able to actually remember anything after the long summer break. I didn't realise how much the different areas interlinked"
>
> "Did not think I would have been able to think of enough things after 3 months but found things start to come back once I started writing"

These comments illustrate that these students were well aware of their own thought processes during this task, and were even able to compare the difficulty of the work with their initial expectations on being given the task. Some of their comments specifically referred to the nature of the task:

> "I think this exercise was useful as it let me know exactly how much I know about energy, which I can now see is not enough"

> "I found I was digging around, trying to put fragments of things I could remember together. I found I could remember only scraps of information, but when doing the drawing, saw how things pieced together, and linked with other things"
>
> "Quite useful, brings back memories; good to see how well topics relate or how well you can interrelate them"
>
> "At first I did not know where to start but as I began putting ideas down, it reminded me of other points. I could have carried on writing"

These comments suggest that - for some students at least - concept mapping is an activity where the learner is able to offer judgments on current learning which can form the basis of planning future study.

Concluding comments

My decision to ask the students to report their reactions to this lesson was spontaneous, and - like many 'spontaneous' decisions that have their genesis in a longstanding concern that has been the subject of much critical reflection - it proved to be a rewarding one. Reading the students' comments set in train thoughts that I felt motivated to commit to paper. In particular it reminded me that valuing the affective side of student development, and encouraging metacognition, are not alternatives to teaching cognitive content. In this lesson students thought about physics, and thought about their thinking, and thought about their feelings about the experience. I learnt about their current state of knowledge and some of their misconceptions, but I also learnt that concept mapping was one technique that students in this group found enjoyable, interesting and useful. But this paper is about student reactions, so I will leave the last words to them:

> "I didn't think I'd be able to actually remember anything after the long summer break. I didn't realise how much the different areas interlinked. You could go on and on forever. I think this is a very pleasant experience and something I shall intend to continue doing."
>
> "Having never done one of these maps before I was amazed at what I was coming out with and could vaguely remember after three months off! I hope the rest of the course is like this."

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