Many pupils have misconceptions in Science. To identify pupils' misconceptions in Science, questioning, written tests, assigned problems and worksheets are some methods which are often used. Examining these methods critically, one may see that these methods provide fragments of information of pupils' misconceptions. What these methods can diagnose will just be limited to certain pre-determined or artificial scientific misconceptions taught by teachers. They cannot give a full account of pupils' understanding and misconceptions.

This problem can be overcome, if one applies pupils' concept maps in diagnosing their learning outcome. Figure 1 below shows a concept map given by a pupil at secondary three level after he has studied the topic "redox reactions" (Seah, 1984).

![Figure 1. A Pupil's Concept Map](image)

This concept map can be broken down into four components for ease of discussion.
(a) In Figure 2a below, the key concept "redox reaction" is correctly linked to the related concepts "oxidation" and "reduction" in a hierarchical order. However, the pupil does not show the complete relationship (i) between redox and oxidation, and (ii) between redox and reduction.

\[ \text{redox reaction} \]
\[ \text{oxidation} \quad \text{occurs with} \quad \rightarrow \quad \text{reduction} \]

**Figure 2a**

(b) Figure 2b, below, shows that the pupil knows that corrosion involves oxidation, but he does not realize that corrosion also involves reduction. While a metal is being oxidized to form a metallic oxide, oxygen is also being reduced by the metal to form the oxide.

\[ \text{occurs with} \]
\[ \text{oxidation} \quad \rightarrow \quad \text{reduction} \]
\[ \text{e.g.} \]
\[ \text{corrosion} \]

**Figure 2b**
(c) In Figure 2c below, the pupil links oxidation to oxygen and reduction to hydrogen, and misses out the cross links. He probably does not understand the complementary nature of the addition/removal of oxygen and hydrogen. If this is the case, then the teacher has to emphasize on this complementary nature.

![Diagram of oxidation and reduction involving oxygen and hydrogen]

**Figure 2c**

(d) In Figure 2d below, the pupil links the electron to reduction and not to oxidation. It is possible that he only recognizes the involvement of the electron in reduction, but is not very sure of the relationship between the electron and oxidation. He may not realize that oxidation involves electron transfer.

![Diagram of oxidation and reduction involving electron]

**Figure 2d**
What is a Concept Map?

From the examples above, we see that a learner's concept map is a way of showing how his knowledge is structured and the extent the learner has perceived the concepts involved. In principle a concept map should be able to:

- link related concepts (or terms) together; and
- give meaning(s) for each link.

Generally, the concept maps constructed by different people need not be the same. A good example of a concept map on redox reaction is shown below in Figure 3. This type of map is usually constructed by experts, teachers or good pupils who know the topic well. By comparing the learner's concept map to such a map, certain misconceptions of the learner may be identified.

![Figure 3. A Good Example of a Concept Map](image-url)
The significance of using concept maps in teaching and learning, which has been pointed out by Brumby (1983), is that concept map shows pupils the importance of making links between new and existing knowledge. In preparing a concept map of a topic learnt, pupils are required to actively re-sort ideas, and actively relate new ideas. Both these active processes are significant steps towards meaningful learning and can overcome the passive rote-learning of isolated ‘bits’ of knowledge.

From Figure 3, we notice that the design of a good concept map is simple. Even a primary school pupil can be trained to construct it. A learner is free to express himself in organizing the map. Moreover, the qualitative interpretation can also be made in the map without difficulties. A good concept map is logical, and all those concepts involved are often arranged logically in a hierarchical order. Hence, this simple diagnostic technique is very suitable for classroom teaching.

**How to Implement?**

To make concept maps a useful tool for diagnosing pupils misconceptions, we must train our pupils in constructing their concept maps.

Novak (1981) has suggested a series of sequence for a learner to construct a concept map:

(a) Select a topic/key concept;

(b) Identify other related concepts;

(c) Rank all the concepts involved in a hierarchical order from the most general to the most specific;

(d) Link all the concepts involved with lines; and

(e) Write appropriate “logical connective”, e.g. “because”, “therefore”, “involves”, or “consists of”, etc., on (or near) each line.

Teachers should remind pupils to draw all the required lines and never omit the essential logical connectives. They must also try to make concept maps an integral part of pupils learning experience.
What are the Other Implications of Concept Maps in Teaching and Learning Science?

In addition to the advantages described above, a good concept map (e.g. Figure 3) can also be used to:

- organize knowledge of a topic;
- classify information into categories and sub-categories;
- plan instructional sequence as a useful component of the lesson plans;
- show a topical overview at the beginning of a lesson;
- motivate pupils as they usually enjoy constructing it;
- generate questions and discussions of the topic in the class;
- rank the concepts involved and show the relationships between various concepts;
- differentiate the key concept(s) from other concepts;
- consolidate ideas about a topic; and
- summarise and review all the concepts learnt in the topic.

Conclusion

Concept maps constructed by pupils appear to be a very good tool for probing their understanding in Science. In this article, a simple example of concept maps in Chemistry has been described to illustrate how we can use them to diagnose pupils' misconceptions. To make concept maps useful tools for this purpose, a teacher must instruct his pupils to construct their concept maps properly. In addition to gain diagnostic feedback from pupils, a teacher can also use concept maps to introduce, develop, and conclude a lesson.
References


