



A Group Approach to CONCEPT MAPPING

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In the original studies at Cornell University in the 1970s, Joseph Novak, his colleagues, and graduate students labeled concept mapping as a tool for identifying what the learner already knew about a subject area (Novak, 1976). The "map" created by each student gave the educator, as well as each student, a visual representation of the student's prior knowledge and concept understanding. It was believed that in order for successful learning to occur, a student must take active possession of what he or she already knows (as described in a concept map), find a relationship between each concept listed, and restructure the original concept with new terms and new understandings (Novak, 1990). Concept

mapping became a way for students to visually recognize their knowledge and understanding of a topic.

According to Roth (1994), restructuring concepts while situated within a small group setting can greatly enhance the learning process. This peer collaboration allows students to influence and teach one another. In a group, students are able to demonstrate what they know about a subject while listening, observing, and learning from others resulting in the modification of their own understanding. Creating concept maps in groups therefore should unite teaching with learning; teaching by one student and learning by another. The end result of a concept map generated by a group of students is educationally directed social interaction by students, a product consisting of the combined knowledge of two or three students, and at least one (possibly two or three) student from each group who have had the opportunity to directly teach a fellow classmate

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(Novak & Gowin, 1996; Okebukola, 1992; Lumpe & Staver, 1992).

Concept Mapping

The physical structure of a concept map is designed for the benefit of the student and the teacher. Students create a map, review, and modify their ideas by what was drawn and written, then present to their teachers a diagram representing students' knowledge and organization of that knowledge. Novak's visual schema begins with the most general, inclusive concept at the top of a hierarchical diagram and proceeds downward to less general concepts and finally to specific examples (Novak, 1976). Some educators evaluate the maps using the number of concepts, links and cross-links as criteria for a grade (Novak, 1981; Novak & Gowin, 1996; Regis & Abertazzi, 1996). The links between concepts show relationships between concepts and the number of cross-links can show the degree of integration between concepts (Pearsall, Skipper & Mintzes, 1997).

Social Constructivism

According to Ausubel (1968), "The most important single factor influencing learning is what the learner already knows." Novak and Gowin (1996) acknowledge that prior knowledge is important but add that student learning is greatly affected by the environment in which instruction and learning occurs. The majority of today's high school science classrooms still have the teacher as the center of all classroom activity (lecture being the predominate method of instruction). Due to cable television, computer programs, and reference material, and the much-used Internet, high school students have a wealth of knowledge that could be tapped into. They arrive in class with a wide variety of experiences and degrees of understanding on the topic to be learned. Teachers need to find a way to pool the resources and experiences of all students to make learning more meaningful. Group concept mapping is one way to get students actively involved in learning by using their knowledge to teach the rest of the class.

In today's high schools, teaching students about the chemical processes occurring in plants using terminology difficult to pronounce (cellular respiration, stroma, and co-enzyme A) is a difficult task for teachers. According to the constructivist view, one problem with lecture, and teachers requiring rote memorization is that students only receive a fragmentation of knowledge (Songer & Mintzes, 1994). Today, however, most educators from middle school on up through graduate school use this instructional strategy without hesitation (Schmidt & Telaro, 1990; Tobin & Gallagher, 1987; Ruiz-Primo & Shavelson, 1996). Some high school

teachers have found that using students to teach students not only helps one party to understand concepts, but also strengthens the other party's confidence and understanding (Lumpe & Staver, 1995).

Group Mapping

Concept mapping is ideal for trying to determine conceptual understanding of concept-rich subjects that high school students may find difficult to understand. Confusion and misunderstandings regarding photosynthesis and cellular respiration have been well documented (Haslam & Treagust, 1987; Amir & Tamir, 1994). Allowing students to work in groups to diagram their understanding of photosynthesis and cellular respiration on paper, in an organized map (or maps), would enable teachers and students alike to determine student understanding. Working in groups provides several ways for learning to occur. First, mistakes showing a lack of understanding of one or more students are evident. Students will correct each other's mistakes while interacting to create a final version of their map. Second, all interaction taking place to create a joint map will result in biology discussions instead of on upcoming weekend activities. And finally, group mapping allows those who do not fully understand a topic to get explanations from some of their peers who do understand, and allows those giving the explanations to develop a greater depth of understanding of the topic. Students teach one another and learn from one another, all the result of a concept mapping assignment. An example of a concept map created in a small group in this study is seen in Figure 1.

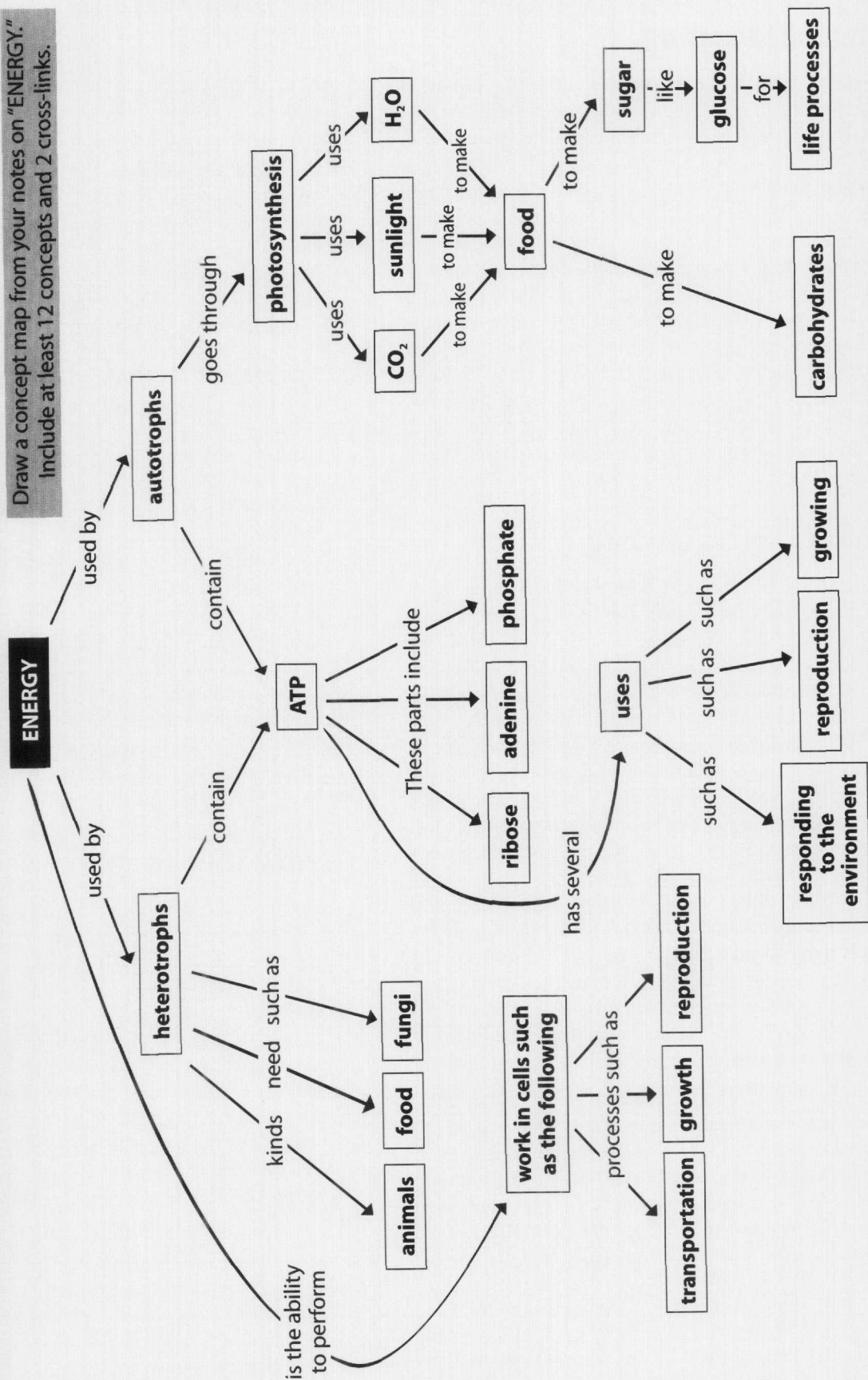
Theory into Practice

In a recent study, student understanding of photosynthesis and cellular respiration was identified after concept mapping was used by 97 students in their biology classes. The study looked at students taking an Introduction to Biology class in a Midwest suburban high school. Introduction to Biology is described by the course syllabus and by guidance counselors as one that is geared for either non-college bound students or those who have had trouble with science courses in the past. The majority of the students in the biology classes were sophomores. Pre-and post-tests were administered and gain scores were used as a dependent variable.

Prior to instruction of the photosynthesis unit, all biology students involved in the study underwent 10 weeks of intermittent instruction, using group and independent practice, on the creation and use of concept maps in the classroom. The week before the study started, a pre-test was administered to the students to test their knowledge of photosynthesis and cellular

Figure 1.

A concept map on "Energy" created by 3 students in a group concept mapping class.



respiration. The assessment tool used was a 2-tier test constructed by Haslam and Treagust (1987) titled, "Two-tier Photosynthesis and Cellular Respiration Test".

The high school biology teachers involved in this

study pooled their lecture notes and created 10, 15 to 20 minute mini-lectures (Figure 2). These mini-lectures were given by each instructor at the same time on the same days by following the same script. Although lec-

ture oriented, these teachers also agreed to include a variety of activities in their classrooms in an effort to best get across all of the concepts represented in this concept-rich unit. All activities were used by each teacher on the exact same days, and the same format was followed for each class period. These additional activities included two labs, a video, two weekly projects, and several problem-solving reviews and activities.

In this study, two biology teachers each taught three sections of Introduction to Biology. The control group represented biology classes that did not use concept mapping during the photosynthesis and cellular respiration unit. The two experimental groups represented classes in which students created their concept maps on their own and classes where students worked in small groups to create maps through collaboration. Each teacher taught one control group section, one individual mapping section and one group mapping section. Both teachers gave the same lectures, used the same assignments, and followed the daily agenda. The only difference in the agenda between the control and experimental groups relates to the construction or non-construction of the concept maps. A sample of a daily agenda is seen in Figure 3.

Students constructed concept maps the final 15 minutes of each 50-minute biology class. Every other day during the study, the experimental groups spent the remaining class time constructing concept maps, either as individuals or in small groups. The control group was given an assignment over the same material with time for all who finished early to work on other class assignments (see Figure 3). Concept maps were collected at the

Figure 2.

Mini-lecture, created by biology teachers pooling their notes, to be presented to all biology classes.

What is Photosynthesis?

Photosynthesis is defined as the process by which autotrophs (plants) convert sunlight into a useable form of energy.

Photosynthesis requires:

1. light energy – from the sun
2. water – absorbed from the soil by the roots of plants
3. CO₂ – from the air – enters through the green leaves and green stems
4. chlorophyll – a pigment in plants

Photosynthesis produces:

1. glucose – a carbohydrate – used for life processes
 2. O₂ – gas released into the atmosphere – exits through green leaves and stem
- $$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_3\text{H}_6\text{O}_3 + \text{O}_2$$
- (carbon dioxide and water are changed into carbohydrates and oxygen gas)
- Photosynthesis **only** occurs in the presence of light energy.
 - No photosynthesis occurs at night!

Figure 3.

One day's agenda for teachers to follow during the photosynthesis unit.

Day 7 Agenda

1. Teacher presents overhead notes titled "Types of Cellular Respiration."
2. Teacher presents overhead notes titled "If Oxygen is Present."
3. Students view a video titled "Photosynthesis and Cellular Respiration."
4. Students take 10 facts on the video relating to the photosynthesis unit.
5. Research using Concept Mapping:
 - a. Individual mapping class will construct concept maps on cellular respiration using notes and facts from the video. Each student is required to create his/her own map.
 - b. Group concept mapping class will construct concept maps on cellular respiration using notes and facts from the video. Students, in small groups of two or three, will turn in one map per group.
 - c. The no mapping class **will not** construct concept maps. This class will take their notes and facts from the video and write a 1-page summary of their understanding of cellular respiration.
6. All classes will work on their weekly projects if there is extra time left in class.

end of class and evaluated on accuracy and degree of hierarchical development. To ensure consistency in grading, all maps were scored by one individual using a scoring guide.

Table 1.

Adjusted gain means and standard deviations of the control and experimental groups.

	No-Map Group (Control)	Individual Mapping Group	Group Concept Mapping
Introduction	M=0.86	M=0.49	M=2.34
To Biology	SE=0.62	SE=0.52	SE=0.56

M = mean of gain scores SE = standard error

Figure 4.

Two-tier test question #8.

Test item #8. When do green plants respire?

1. Only at night (when no light energy is present).
2. Only during the daylight (when there is light energy).
3. All the time (whether there is light energy or when there is no light energy).

The reason for my answer is because:

- a. Cells of green plants can photosynthesize during the day when there is light energy and therefore they respire only at night when there is no light energy.
- b. Green plants need energy to live and respiration provides energy.
- c. Green plants do not respire, they only photosynthesize, and photosynthesis provides energy for the plant.

Table 2.

Each possible answer from test question #8 along with percentages of students choosing each answer for experimental and control groups.

		Reason choice (% for group mapping/individual mapping/control groups)				
Question #8	Content choice	A	B	C	D	Total %
	1	3/8/18	1/1/2	0/0/1	0/1/0	35
	2	1/2/2	1/2/2	0/1/0	0/0/1	12
	3	1/2/1	22/14/8*	0/0/2	1/0/2	53

* Represents correct content and justification choice

Results & Implications

The results indicated that the classes involved in group concept mapping outperformed the classes where students created concept maps as individuals or did not concept map at all. From pre- to post-test, students on average increased their scores by more than 2 questions in the group mapping classes as compared to increasing scores of approximately one question in both the other two groups (see Table 1). The control group mean (No Maps, $M = 0.86$) was slightly greater than the mean of the Individual Maps group ($M = 0.49$), yet was significantly lower than the Group Maps group ($M = 2.34$).

Figure 4 shows Question #8 from Haslam and Treagust's (1987) two-tier test and Table 2 shows results from this question. This question was designed to test students' understanding of the concept that respiration is a process that occurs continually in all plants (day or night) providing plants the energy to live. Forty-four percent of the students correctly answered both parts of the two-tier question on the post-test. As seen in Table 2, half of all students who correctly answered this question were members of the concept mapping classes where maps were created in groups. Thirty percent of the students who correctly answered the question were students who created concept maps as individuals and the remaining 20% of the students who correctly answered both parts of the two-tier test question were in the control group. Results from this test question show the effect of working in groups on understanding of biology concepts.

Summary

Concept mapping has been shown for the past 20 years as being an ideal strategy for promoting meaningful learning (Pankratius, 1990; Okebukola, 1992; Novak, 1976; Novak & Gowin, 1996). Lumpe & Staver (1995) demonstrated that students who created concept maps in small groups outperformed students working on their own. The results from this study validate that by Lumpe and Staver (1995) showing that students who create concept maps in small groups

outperform those who create concept maps as individuals or who do not create concept maps at all. In a concept-rich unit such as one on photosynthesis and cellular respiration, students are able to talk through misunderstandings of science concepts and teach one another these biology concepts in high school classrooms where mapping in groups occurs. Once on paper, all members of a group can observe, agree with and modify explanations prior to turning them in for a grade. Even students can see the benefit of using concept mapping and working in groups on assignments. One student wrote, "These [group concept maps] maps are kind of like a jigsaw puzzle. We can all add pieces to make the final product. If we make a mistake, others can help us out so we understand what we did wrong."

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