Using Cooperative Learning in the Teaching of High School Biology

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Background Information

"I don't understand!" remarked a 10th-grade biology student. "This graph seems to indicate that photosynthesis in land plants slows down between 1 p.m. and 4 p.m. on most summer afternoons. I would have predicted it would be at its greatest about then".

"Let me see the graph," remarked another student. "This line represents stoma opening in plants, not photosynthesis rate. Can't sugar development still be high during the afternoon?"

"But aren't they directly related?" inquired a third student. "How can CO_2 enter the leaves of a plant for photosynthesis if the stomata are closed?"

"Maybe plants can get CO_2 some other way," remarked a fourth student. "Don't plants have openings in their stems as well as their leaves?"

Discourse of this type is commonly heard from small groups of students during biology classes taught through cooperative learning. Highly praised in recent years by educational theoreticians (Hillkirk 1991; Slavin 1990), cooperative learning encourages students to interact in small learning groups of three or four students. Problematic tasks drawn up by the instructor are performed and discussed by members of each team. The objective of the group is to come to a consensus on a solution to the task and report this conclusion to the class. Group size is purposefully small to assure that all students in the group have an opportunity to discuss the issues. Heterogeneity of the group is important for the model's success, and team questions are structured as open-ended as possible. In the group settings, personalities and other social concerns seem to evaporate after a few weeks; constructive learning is regularly found in all of the groups by the second or third session.

Cooperative learning has been effectively used in elementary school instruction for several decades, but it has only recently found its way in the classrooms of teenagers. Most of the use with cooperative learning in the secondary school, however, has been focused in English, humanities and the social sciences, not in the natural sciences (Brophy 1989). Studies in these subject areas indicate that cooperative learning is as effective a teaching strategy with older students as it is with younger ones.

Investigating the learning outcomes from numerous research reports on the topic, Shroyer (1989) came up with 12 experimentally proven benefits of using cooperative learning in classroom instruction. These outcomes are:

1. Higher achievement and increased retention
2. Greater use of higher level reasoning strategies, increased critical reasoning strategies and increased critical reasoning competencies
3. Greater ability to view situations from others' perspectives
4. Higher achievement and greater intrinsic motivation
5. More positive, accepting and supportive relationships with peers regardless of ethnic background, sex, ability or social class differences or handicapping conditions
6. More positive attitudes toward subject areas, learning and schools
7. More positive attitudes toward teachers, principals and other school personnel
8. Higher self-esteem based on self-acceptance
9. Greater social support
10. More positive psychological adjustment and health
11. Less disruptive and more on-task behavior
12. Greater collaborative skills and attitudes necessary for working effectively with others.

With this record, it is puzzling that cooperative learning has not found its way into many secondary school math and science classrooms. Investigating the phenomena, Lipson and Tobias (1991) concluded that science and math continue to be taught in most high schools in the traditional lecture-laboratory mode. This has occurred despite urging from the American Association for the Advancement of Science, the National Association of Biology Teachers, and the National Science Teachers Association for teachers to adapt less traditional teaching methods in their instruction.

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Indeed, a few recent studies have investigated whether cooperative learning can enhance student understanding in high school science and mathematics. Steffe and Woods (1990), for example, found cooperative learning in secondary school algebra and geometry to be an effective way of improving students' knowledge; and Basili and Sanford (1991) noted that cooperative grouping enhanced their students' ability to recognize misconceptions in chemistry. Watson (1991) reported improved student understanding of basic life science concepts with cooperative learning teaching, and Newell (1990) concluded that cooperative learning instruction produced greater analytical, critical and conceptual skills in biomedical engineering students. Convinced that cooperative learning can significantly improve a student's achievement in science, the Biological Sciences Curriculum Studies (BSCS) in Colorado recently developed a science curriculum for young teenagers based entirely on the cooperative learning model. Field test studies on the BSCS curriculum have indicated that cooperative learning does, indeed, improve a student's knowledge and understanding in science.

Method

With support from the Pennsylvania Academy for the Profession of Teaching, a study was undertaken to see if experienced biology teachers would find the cooperative learning approach beneficial in their teaching. Fifteen life science teachers from different secondary schools in the state, most of whom held master's degrees in biology and had been teaching more than a decade, produced a series of biology lessons using cooperative learning techniques to see if the strategy could enhance knowledge in their students. The participants were selected for the study from more than 50 applicants through a letter of interest on why they wished to learn of a new, effective way of teaching their courses. Some of the applicants wished to learn a different approach to teaching biology; others needed to find an effective way to excite their students in the material; while still others wanted to find how cooperative learning fit in the teaching of life science. By the conclusion of the project, all of the participants felt they had accomplished their initial objective.

The participating teachers met together for three consecutive days in the autumn to hear about cooperative learning from life science teachers who were using it successfully in their classes. The teachers also heard how cooperative learning encompassed the vast number of learning styles of their students and how to construct cooperative learning-based lessons. By the end of the three-day session, the teachers were anxious to try cooperative learning activities with their classes. They were each given a blank videotape to record their trials with their students and were told to bring four or five of their most successful lessons with them to share with other participants when the group reassembled in the spring. Contact with the participants was maintained throughout the winter months by phone and/or personal visitations.

The teachers returned to the university for three nonconsecutive days in the spring to share their experiences and the lessons they had created. Before departing in the autumn, workshop members had volunteered to make their presentation during either the first, second or third spring session. Each participant was given 75 minutes to present his or her materials to his or her colleagues. During this time, the teacher enthusiastically guided the group through the selected cooperative learning activities they had developed and showed several segments of videotapes of their classes' interactions. Overall, there was great excitement for the project. The teachers reported that their students learned the material as well or better than in years past, and that they enjoyed teaching with cooperative learning. All the participants said they would never return to their old presentation styles again.

To find out if any attitudinal changes in teaching a life science course had resulted from the project, the

Figure 1. Survey of teacher attitudes & opinions about life science teaching (adopted from Atwater, Simmons, Butts & Anderson).

Indicate the number on the answer sheet which best represents your opinion of the following statements: (1) Strongly Disagree; (2) Disagree; (3) Undecided; (4) Agree; (5) Strongly Agree.

1 2 3 4 5	1. Exposing students to "hands-on" activities is the best way to teach life science in schools.
1 2 3 4 5	2. Teaching students to be good observers is just as important as teaching content.
1 2 3 4 5	3. It is better to tell students about biology than to let them discover it themselves.
1 2 3 4 5	4. Asking questions in life science is more important than giving answers.
1 2 3 4 5	5. It is more fun to teach life science than the other sciences and mathematics.
1 2 3 4 5	6. It is more fun to teach life science than academic subjects outside of science and mathematics.
1 2 3 4 5	7. Life science is more practical for the students to learn than other sciences and mathematics at the secondary level.
1 2 3 4 5	8. Student discussions during life science instruction are usually a waste of time.
1 2 3 4 5	9. Life science field trips are usually more trouble than the benefit they provide the student.
1 2 3 4 5	10. Labs in life science are usually more trouble then the benefit they provide students.
1 2 3 4 5	11. Computer simulations and videodisc programs should be utilized in place of laboratories whenever possible.
1 2 3 4 5	12. I feel uncomfortable using life science equipment in the laboratory.
1 2 3 4 5	13. I feel uncomfortable in laboratory investigations where live animals are used.
1 2 3 4 5	14. I feel uncomfortable in lab investigations where preserved animals are used.
1 2 3 4 5	15. Teaching content in biology is more important than changing attitudes in science.
1 2 3 4 5	16. Multiple references are more desirable than a single text for teaching biology.
1 2 3 4 5	17. Life science teachers should be learning facilitators rather than lecturers.
1 2 3 4 5	18. Student interaction and exchange of ideas is as important as content in life science teaching.
1 2 3 4 5	19. It is important to relate biology material to everyday life as often as possible.
1 2 3 4 5	20. Life science teachers should know the subject matter in-depth before they attempt to teach it.

participants were given a questionnaire, constructed by Atwater et al. (1990) at the University of Georgia, which was designed to measure beliefs and attitudes of life science teachers (Figure 1). Since this survey was initially produced for junior high school teachers, minor modifications in the instrument were necessary. The survey was given to the teachers in the project at the initial session in the autumn and again during the final session in the spring. Statistical comparisons of the pre- and post-surveys were made, and significant changes in attitudes of the population were noted.

Discussion of the Outcomes

The comparisons between pre-workshop and post-workshop teacher attitudes reveal some startling differences (Table 1). Shifts in teacher attitude occurred in more than half the questions, and two of the survey items registered statistically significant differences. Before the project, about half of the teachers had stated that computer simulations and videodisc programs should be used in place of labs whenever possible. After witnessing the effectiveness of cooperative student groupings in laboratory investigations, only 20% of the teachers agreed with the statement. Significant changes in attitude also took place on the content/process question in the survey. At the onset of the project, 60% of the teachers felt that teaching life science content was more important than affecting the students' attitudes in the discipline. By the end of the workshops less than a quarter of the participants felt that way.

In addition to the Atwater et al. survey, the participants were asked their feeling on the cooperative learning approach to teaching. The majority of the teachers found the experience surprisingly beneficial. Some found the introductory days of the project to be extremely informative, while others thought the spring presentations by their workshop colleagues to be the most rewarding. One participant felt that so much work was required to develop and present the cooperative learning activities to their students that graduate credit should be awarded to all those who completed the objectives. All of the participants found cooperative learning to benefit their students, and all said they were planning to use the strategy in teaching life science in future years. The only problem listed by a few of the participants concerned those who would be teaching colleagues in their home institutions who are convinced that the traditional teaching styles are the only ones that work with teenagers.

Instructor enthusiasm for teaching with cooperative learning was seen in the life science activities they developed. Many of the cooperative learning sessions centered around the students' laboratory investigations. One teacher used the cooperative group approach in dealing with surface area-volume relationships in cells. Another participant had the students investigate karyotyping of chromosomes, while another used cooperative learning to investigate student blood pressure. Some of the teachers

Table 1. t-test analysis of the pre- and post-teacher attitude survey.

Question	*Version*	*Mean*	*SD*	*t-Score*
1	pre-test	2.00	0.00	0
	post-test	2.00	0.00	
2	pre-test	1.86	0.35	1.33
	post-test	2.00	0.00	
3	pre-test	1.14	0.36	1.19
	post-test	1.00	0.00	
4	pre-test	1.93	0.26	0.98
	post-test	2.00	0.00	
5	pre-test	1.67	0.48	1.25
	post-test	1.86	0.35	
6	pre-test	1.80	0.41	1.33
	post-test	2.00	0.00	
7	pre-test	1.67	0.48	0.81
	post-test	1.80	0.41	
8	pre-test	1.14	0.36	1.92
	post-test	1.00	0.00	
9	pre-test	1.57	0.51	1.69
	post-test	1.27	1.46	
10	pre-test	1.43	0.51	1.19
	post-test	1.00	0.00	
11	pre-test	1.24	0.49	2.60*
	post-test	1.68	0.41	
12	pre-test	1.28	0.47	0.98
	post-test	1.13	0.35	
13	pre-test	1.28	0.47	0.98
	post-test	1.13	0.35	
14	pre-test	1.14	0.36	0.07
	post-test	1.13	0.35	
15	pre-test	1.14	0.49	3.20*
	post-test	1.63	0.35	
16	pre-test	1.16	0.48	1.28
	post-test	1.86	0.35	
17	pre-test	1.73	0.45	1.47
	post-test	1.93	0.25	
18	pre-test	1.64	0.49	1.29
	post-test	2.00	0.00	
19	pre-test	1.93	0.26	1.35
	post-test	2.00	0.00	
20	pre-test	1.93	0.26	0.59
	post-test	1.87	0.35	

* $p < .05$

used the method for terminology acquisition having the small student groups teach each other the lesson's vocabulary. The teacher then quizzed one person in the group on the words, and the student's score was recorded for all the team's members. An off-shoot of this approach was used by a few participants as they assigned different material in the following day's lesson to different students in each group. The following day the students taught the other members of their group the information for which they were responsible. Still other teachers in the project used cooperative learning in assigning team projects from classroom or fieldwork experiences. After a few weeks the student teams presented their cooperatively constructed projects to the entire class (in unified-group fashion). Each member of the team received the same grade for the group's project.

Table 2. Course means of cooperative learning and traditionally taught students.

Population	*Df*	*Mean*	*SD*	*SE*	*t value*
Cooperative learning	99	.85	6.9	.7	4.34*
Traditional instruction	99	.81	8.2	.8	

* $p < .05$

Does the cooperative learning approach to teaching truly affect the student's understanding of the material? Past research into this question revealed that a person's knowledge and comprehension of the subject matter does indeed rise significantly (Sharan & Sharan 1990). The research also has found that the critical reasoning level in students greatly improves, and their knowledge of the material is more enduring, when they are taught with cooperative learning rather than with traditional teaching methods. While long-term analysis with the students in this project is not yet possible, a comparison of the final biology averages of the teens from the project can be made with the final averages on the same material from students in past years. Course means from 100 biology students taught with cooperative learning by the participating teachers were randomly selected from the larger student population and compared to the final averages in biology from the previous year in the selected teacher's classes. This analysis revealed a significant rise in achievement and understanding in the cooperative learning students (Table 2). Overall, group means increased an average of 4% in the student groups taught by cooperative learning when compared to those taught in a traditional manner.

Furthermore, there was a recognizable difference in the way the cooperative learning students felt about biology compared to students taught in past years with a more conventional approach (as revealed from the student evaluations). The majority of the students taught by cooperative learning said they enjoyed coming to class and learning from each other. This was not the case with most of the students in traditional life science classes taught by the teacher participants. Most of this population were enthusiastically lukewarm on the subject and rated it no higher than their other subjects in school.

Final Comments

One of the major goals of any teacher is to excite students for the discipline. Master teachers are generally able to engender the same love and respect they have for the subject to many of their students. The task is arduous and demands persistent student challenge and reward. It requires patient teacher guidance and modeling to bring students to the point of scholastic understanding and confidence in a discipline.

Science, as it is presently taught, however, has a particularly difficult task in promoting this attitude in students. Whereas disciplines outside of science are generally taught in a nonthreatening and noncompetitive fashion, science courses tend to be unapologetically selective and intimidating. As such, many bright, capable students turn away from science. Some educational theorists suggest that, for many students, the rejection of science is really a rejection of competition. Instead of engendering intrinsic admiration for the subject, science too often emphasizes extrinsic rewards (grades) and objective goals (getting into medical school).

The cooperative learning teaching strategy can help science overcome this negative image. The method creates a caring, nonthreatening environment in which positive reinforcement, creativity and understanding of the subject can flourish. Cooperative learning enhances achievement, encourages critical thinking and increases retention. It develops higher self-esteem and greater appreciation of others, and creates an agreeable environment for learning. All told, cooperative learning provides a teacher with the means of igniting in students a true love and passion for biology.

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