Cooperative Learning That Really Works in Biology Teaching

Using Constructivist-Based Activities To Challenge Student Teams

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THERE is an old Chinese proverb that reads, *If I hear—I forget, If I see—I remember, If I do—I understand.* Seasoned educators know, however, that seeing and doing can lead to forgetting as well. Simply viewing the material will not automatically lead to remembering, and working with something will not automatically lead to understanding. For lasting learning to take place, students must be actively involved in thinking about what is being heard, seen or done.

For example, students in biology laboratories sometimes perform investigations without understanding what they are doing. Indeed, so widespread has the idea of "hands-on education" become in our schools that students have become skillful at setting up learning situations, following directions, performing activities, and cleaning up after themselves. In fact, students have become so competent in the "hands-on" format that they can answer questions on a performance sheet or describe what they have completed in an activity report without totally understanding what they have just accomplished.

I watched a high school lab in advanced biology exploring the embryologic development of amphibians. Each student observed preserved stages of developing frog eggs in petri dishes under a dissection scope and arranged them in order from zygote to tadpole, drawing each stage as he or she went along. In a late stage, organogenesis was introduced and the students read what organ systems developed from the various layers. The participants worked quickly and efficiently through their task, completing it before the lab ended. I returned the following week to find out how the students had done on their exam on the subject. Grades on the test revealed that the "learning" of the subject matter was very high in this group of high achievers. Yet when I asked students if they could draw correlations between systems from the same germ layer in the gastrula or predict outcomes that were not directly in their notes, most could not do it.

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Studies find that it is not unusual for students to misunderstand and retain information they have successfully passed in their courses (Astin 1985). Tinto (1987) found that many students cannot apply the information they have in courses to common, every-day situations and Daloz (1987) concluded from his studies that most students in high school cannot make comparative relationships between the factual content they have learned. Perkins (1994) found that many students continue to hold misconceptions about course material they have successfully passed on recently taken exams.

Why can't many of our students make connections between things they know? Is it because of the poor study habits of today's students or the difficult reading levels of contemporary science textbooks? Perhaps the reason students aren't retaining or understanding information they are taught is due to the way we are teaching.

How often do we, as biology teachers, ask students to draw connections between things we teach them? Do we encourage students to apply the concepts they learn to things outside the lesson? In many biology classrooms, all the instructional time is spent going over the factual content in the text. Despite the teachers' acknowledgment that the primary goal of teaching is for students to understand and be able to apply the material, many feel pressure to cover as much of the content in the textbook as they can. Unfortunately, in many schools it is the content in the textbook or an exit exam that drives the biology curriculum.

Furthermore, many biology teachers continue to support the assumption that content recitation confirms content comprehension. This is supported by the fact that most of the biology exams given to students across the country focus on the facts covered in the unit. The few exams that do include open-ended, subjective-type questions are still heavily laden with questions that depend solely on rote memory (Menges 1988). With the emphasis on nomenclature rather than comprehension, it is no wonder that the students of today have misunderstanding about biology. When the evaluation of what they know is based on rote memorization and reiteration, students don't expend the additional cognitive energy that is required to apply the information to other situations and truly comprehend the subject. If the goal of our instruction is to develop students who are enthused about biology and really understand the material, we need to drastically modify the way we teach.

Before we can make changes in our teaching methods, however, we should consider what is really involved in the way the students acquire knowledge. Learning psychologists point out that knowledge is something that resides within one's body, not outside it in biology textbooks and lecture notes. New knowledge results when information encountered cognitively interacts with what the learner already knows. Through this interaction, the biology student attempts to fit the new information with mental notions that are already perceived and understood from his or her past experiences. Once the new information is properly assimilated with the old, real understanding of the issue is reached and a new level of biological knowledge is gained.

Learning theorists term this view of knowledge acquisition "constructivism." Constructivist educators believe that students make sense of what they are presented by associating it with prior knowledge. Once the newly gleaned information is implanted on the person's existing knowledge, the learner is enlightened on the subject and can interact, describe and exchange his/her new insights with others. By attempting to explain what one knows about a topic to someone else, explainers test the fit of their understanding of the material. Similarly, while trying to understand what a colleague is saying, listeners question and challenge their own understandings and try to fit the material into their already established cognitive foundations. In the learning process, mental energies are expended by both the deliverer and the receiver. In a traditional, teacher-directed classroom the expenditure of cognitive energy that enables listeners to cement new knowledge on their existing foundations rarely exceeds 10 to 12 straight minutes. In a student-directed classroom, however, cognitive energy continues to be expended for most of the class period (Wilson 1987).

Using Constructivism in Biology Instruction

Although constructivism gives us an idea about how learning takes place, using constructive methods in biology teaching presents a real challenge. The research literature on the philosophy reveals that the constructivist style used by one practitioner often differs significantly from the method used by another in a second discipline (Good 1993). One of the most successfully utilized constructivist methods for biology is the "5 E" model developed several years ago by Rodger Bybee of the Biological Sciences Curriculum Studies (BSCS). Bybee (1993) based his model on the once popular Science Curriculum Improvement Study (SCIS) learning cycle. According to two researchers that scrutinized the model, the SCIS learning cycle provides an excellent foundation on which to build constructivist-based lessons because it encourages peer interaction in resolving instructor-generated problems (Glasson & Lalik 1993). Bybee's constructivist design focuses on five instructional phases: Engage, Explore, Explain, Elaborate and Evaluate. The Engage activity motivates the class for the topic; the Explore segment encourages the students to examine the topic in small groups; the Explain segment allows them to describe to other members in the class what their team has discovered; the Elaborate permits the students to expand on the topic; and the Evaluate activity provides the students a means of assessing what they have learned. The 5 E model was recently utilized in a large General Biology course for nonscience majors in a midsize university. The results indicated that the undergraduates in the course scored significantly better on the biology exams and enjoyed the course more than the students in traditional teacher-directed biology classes (Lord 1996).

Despite what the research shows about the benefits of using such student-centered, constructivist-based instructional methods, the vast majority of biology teachers still conduct their classes in a teacher-directed fashion (Yager 1991). A survey of several hundred high school and college biology instructors indicates there are several reasons why teachers continue to use instructor-directed methods (Lord 1994b). One of the major reasons given by biology educators for not using cooperative learning in their instruction is that they believe the instructional method they presently employ is effective in getting what is essential across to the majority of their students. Most of these teachers state that they have used their science teaching practices for years and will strongly resist any change forced upon them. Interestingly, several biology teachers in this group claim that, despite their teacher-centered instruction during class presentations, they have been using cooperative learning for years in the laboratory segment of their course where students work with teammates to complete specific lab exercises. Like many teachers, these instructors wrongly equate any form of group work with cooperative learning.

The survey found, however, that many biology teachers were willing to adopt new forms of instruction to their teaching if they were sure it would lead to higher learning in their students. Many of these educators, however, had misgivings about cooperative learning and other forms of student-centered instruction. Countless teachers in this group said they had tried to use cooperative learning in the past but found their best students did not learn as much and their not-as-advanced students "fooled around" and did not learn with the method. Another large group said it had tried student-centered teaching practices in past years but had gone back to a traditional format because it could not cover all the content to which it was accustomed. Some of the surveyed teachers said that cooperative learning worked well in the arts, humanities and the social studies, but that it didn't work in science-related subjects. According to this group, science is built around undeniable truths, facts that each student must know to pass the subject. Most supporters of this position believed that science content can't be learned through shared cooperation. Rather, each individual must learn the information on his or her own.

Resistance to Cooperative Learning

Let's examine these reasons for not using cooperative learning in science instruction. First, we need to realize that some students do succeed in teacher-directed, lecture settings. These kids are generally the best students: academically they read, write and memorize well and are competitive and goal oriented. This segment of the student population will succeed no matter what teaching style is employed by the instructor (McKeachie 1988). A professor I know, for example, recites his lessons to the biology majors in his class for the entire period. He pedantically follows this teacher-directed, lecture format class after class for the entire term. Only occasionally does he use the chalkboard or an overhead projector in his instruction to help disseminate the content he is delivering. Yet, despite his poor teaching style, his students pass most of his standard, objective-style tests that come with the adopted textbook. Although his teaching method is considered poor by present-day standards, the majority of his students are successful in "learning" what is needed to pass the course. In fact, most score high enough to get an A or a B.

It's the other, much larger group of students that we have in our biology classes who have trouble learning from teacher-directed instruction. It's this group of non-rote learners who greatly benefit from breaks in the teacher-directed routine to discuss the relevant information in the lesson with others and to manipulate the material in their minds in an attempt to find a fit with what they already know (Ruhl, Hughes & Schloss 1987). As a matter of fact, it's not just the non-rote learners who benefit from student-directed discussions. Research finds that all kids (even the most gifted) need to do this as well if they're going to hold the information in their heads for an appreciable amount of time (Yager 1991; Lorsbach & Tobin 1994).

Furthermore, the constructivist-based, cooperative learning requires that biology teachers appraise what is important for true understanding of the material and remove superfluous content from the lesson. Many "bioeducators" have for years simply revised their lessons with new material and only marginally eliminated less pertinent information from their presentations. As a result, in many biology classes the content in the courses has increased appreciably over time. Interestingly, research studies have discovered that up to a third of the content in a traditionally taught biology class could be replaced with student-centered exercises that challenge students' learning without sacrificing understanding (Menges 1988). Mayer-Smith and Moon (1993) found that by eliminating superfluous and repetitious content from traditional biology classes, student-focused group activities such as analyzing charts and graphs, constructing concept maps, and answering challenging questions can be included in a lesson without serious consequence. Lord (1996) found that reducing the breadth of coverage in General Biology allowed for greater depth and understanding of the subject by students.

The research has revealed another important aspect of constructivism. Lorsbach et al. (1993) found that as instructors move from traditional to constructivist teaching formats, behavior in the biology class and laboratory undergoes a transition to where the students become more interested in the subject and disrupt the class less frequently. With less time spent in corrective management, the teacher can devote more time to the learning process.

Creating Constructivist-Based Activities

If constructivist-based, cooperative learning is done properly, student learning is enhanced at any level of biology. The reason that some experience failure in their teaching with the practice is that cooperative learning isn't done right much of the time. There are several factors that will doom an honest effort by a teacher to utilize cooperative learning in his or her biology classroom (Table 1). One common exercise that is adversely used as a cooperative learning activity is asking students to do something in their group that can easily be done by one person. In some cooperative learning settings, for example, teachers might ask student groups to copy a diagram from their biology book on a sheet of paper or have

Table 1. Productive and unproductive student-centered learning activities.

Productive	*Unproductive*
• Questions with answers not simply found in the text	• Questions with answers easily found in the text
• Questions that have several answers	• Questions that are too simple for the students
• Questions with answers that are open ended	• Questions that one student has no trouble doing alone
• Questions that require student interpretation	• Questions with answers that are simply memorized
• Questions that are challenging	• Questions with one correct answer
• Questions that encourage students to give their opinions	• Questions that have no relevance to the material being taught

student groups draw a representation of what is seen in the microscope. This type of activity generally involves just one member of the team and creates a poor learning situation for most of the students.

Another exercise often used as a cooperative learning activity in biology and is doomed to fail is that of asking the group of students to do a task that only has one right answer. Some teachers, for example, may ask student groups in a cooperative learning setting to look up definitions of biological terms in the book's glossary or a dictionary. Other teachers may assign cooperative learning teams to look up the answers to questions at the end of the textbook chapter or from a worksheet. Both of these activities have little learning value and are generally seen as busy work by students.

Group work that requires students to simply memorize information is another type of exercise commonly used as a cooperative learning activity in biology which will eventually lead to failure. Teachers, for example, ask students to review diagram labels or vocabulary terms in their cooperative groups for an upcoming test. This activity may keep the students busy for a while but it is not a productive learning experience and it certainly is not constructive-based, cooperative learning.

On the other hand, there are many exercises that frequently lead to a productive, cooperative learning experience for biology students. Activities that contain questions with answers not directly found in the biology book work well for constructivist-based, student work groups. Rather than asking teams to label a diagram on a worksheet in their text, for example, ask them to create a structure placing the diagram labels in some unusual areas. For instance, ask them to create a flower of a submerged aquatic angiosperm and compare it to a typical terrestrial blossom. Remind the students that they must use most of the terms on the book's diagram and be ready to explain their answers. The teams may not know about missing structures or be able to defend all the parts on all their drawings but they will work together and put creative, high-level thinking into their team's effort.

Another constructivist-type exercise that generally works as a cooperative learning activity includes questions that have several answers. For example, rather than teaching the physiology of different organs in one of the systems of the human body through teacher-directed lecture, ask students to come up with the functions of the system's components. If this type of activity is used, it is important to specify a number of functions for each organ. For example, instead of asking students to list "several" functions of the digestive organs (mouth, esophagus, stomach, pancreas, intestines, liver and colon), ask them to give you eight functions of the mouth, three for the esophagus, eight for the stomach, four for the pancreas, eight for the intestines, eight for the liver, and six for the color. When you specify the number of items for each organ, it challenges the student teams and assures that all members will contribute to the answer.

Open-ended questions are also excellent for challenging constructivist groups in biology. Queries that do not have specific answers encourage all members of the team to contribute to the group's answer. An example of this type of question would be to ask teams to come up with 10 actions that industrialized nations could take to help the economies of third world countries, or to ask teams to develop a concept map of direct and indirect factors that would influence habitat conditions in an environment.

Questions that require interpretation are also good cooperative learning exercises. Asking student teams to interpret information from a chart or graph is an excellent constructivist-based, group activity. Another is to have teams solve a question that may be interpreted different ways. Asking groups to come up with at least seven examples of movements in plants, for example, leads to an array of various answers. These might include transport of materials within the plant's vascular tissues, mitotic growth of meristem tissue, surprisingly quick nastic reactions, sunlight-directed diurnal and nocturnal activities, and endocrine-directed tropic and developmental movements. The smorgasbord of answers provides for rich group and class discussion and enlightenment.

Opinion questions are also excellent for simulating constructivist interaction within a group. For instance, asking student groups to come up with five defendable reasons why home owners should have the right to treat their property any way they want and five defendable reasons why home owners should not have that right will generate a lot of thinking within each of the groups.

Examples of other constructivist-based, cooperative learning activities for General Biology are shown in Figure 1.

Managing Cooperative Learning Teaching

Another reason why biology teachers said they did not use student-centered constructivist teaching with their classes was the perceived hassle of incorporating it into the daily instruction. Often, there is so much time lost establishing student groups and handing out the cooperative group materials that half the class period is lost. Instruction time is, indeed, a precious factor in biology teaching. This is why preclass planning is so important in structuring successful constructivist-based, cooperative learning sessions in biology.

The management of the cooperative learning experience need not be a hassle. Many teachers find that if they develop their groups at the onset of each marking period and require the students to sit with their teammates during each class, little time is wasted initiating short group activities during class. One way of doing this that has been successful is to place a different desk or chair number on each course schedule sheet for the marking period. As students enter the class at the onset of the term, they are handed a course schedule from a scrambled stack holding a specific seat number and told to find their new seat for the marking period. As the students locate their new place in the class, they meet the teammates they will work with for the term (Lord 1994a).

The content packet system successfully used with large numbers of cooperative groups will make the management even more efficient. Earlier in the day the instructor places a large envelope with all the easily managed material the group will need for the class. Then, at the beginning of the class period, a member of each cooperative team retrieves the content package from the front of the room. Such items as short readings, information outlines, term sheets, challenge question answer sheets, team quiz results, and even the challenge questions and team quizzes (sealed in different small envelopes) can be placed in the envelope. When it is time for a team activity during class, the instructor asks the groups to pull an answer sheet and/or sealed question from the large envelope and attempt to answer it as a team. When a student group reaches consensus on the answer, someone in the group writes down the

Multianswer Questions

We have learned that, to acquire the materials they need to survive, animals eat different types of food. Some are solely plant eaters (herbivores), some are solely meat eaters (carnivores), and some eat both plants and meat (omnivores). As a team, make a list of 10 animals that fit under each category. After you have done this, arrange the animals in a multi-tiered pattern of who might eat whom if the different animals were all placed in a 25-acre, plant-rich field enclosed by a high chain-linked fence.

The proper functioning of our digestive tract depends on a multitude of enzymes. Under ideal conditions, large foodstuffs are quickly and systematically broken down to very small particles that can pass through the tract's membrane linings. Sometimes, however, the enzyme activity is slowed (or quickened), and even interrupted by certain factors in the digestive environment. See if you and your teammates can come up with a list of at least four factors that will disrupt or enhance enzyme activity.

We've seen that we have three membranes around our brain and spinal cord and that there is fluid (cerebral-spinal fluid) between the membranes. See if you and your partners can come up with three different functions of this multimembrane-fluid coat.

Concept Maps

We know that changes in an environment will affect the plants and animals living there. See if you and your teammates can construct a concept map with 20 environmental factors (both biotic and abiotic) that could directly or indirectly change an area.

There are several ways nature uses to prevent animals of different species from successfully producing hybrids. See if you and your team can construct a concept map with at least 12 ways animals are isolated reproductively.

Scenarios

A local pet store owner purchased a dozen temperature zone South American field toads from a distributor to sell from his shop in town. Several days after he received (and paid for) them, he learned that the toads were listed as endangered by the South American government and that the distributor had illegally obtained them. Calls to the distributor revealed that he had skipped town. Not knowing what to do, and not wanting to get in trouble, the owner decided to release the toads in a large field near the school. As a group, predict what would happen to the freed toads and give a rationale for your conclusion.

Feeling tired after a long job around town, a student drank a pint of Gatorade®, a glucose-rich fluid. Since the monosaccharides in the drink were already in a small, absorbable state, they need no enzyme treatment and were quickly moved through the intestine lining into the blood stream. Soon they were transferred to the tired muscle cells and absorbed through the cell membranes. In 10 minutes, the student felt refreshed and had no muscle fatigue. In fact, the muscles seem "energized." See if you and your partners can trace what happened to the glucose (a) upon entering the cytoplasm (b) when it passed through the membrane of its treated organelle, and (c) after parts of it moved to the center of the treatment organelle.

Chart & Diagram Interpretation

We know that one species can drastically influence another. See if you and your partners can draw population curves for acorns, owls and squirrels in the large park in town as the curves might have looked from 1900 to 1990.

On the board is a line chart that indicates the level of oxyhemoglobin in the blood stream of a fetus. Quantity of blood oxygen is indicated by the vertical axis and the area along the fetal circulatory pathway is indicated on the horizontal axis. The letters on the curve itself indicate specific sites along the blood route. See if you and your teammates can come up with the correct site for each letter.

Problem Solving

If Mary Lyons is correct and only the paternal or the maternal X chromosome is active in any one cell (and the other is dormant), why don't women carriers of diseases such as hemophilia, tintinal deafness and colorblindness express the disease in half their cells? Each group should develop a reasonable hypothesis.

Upon his return to England, Darwin wrote of the huge variations that exist within a single species (1). He also read Thomas Malthus' essay on potentials of population growth outstripping food production (2) and Charles Lyell's book on geological change being persistent and continuous (3). From the three, he formed the backbone of his theory. Discuss with your group what each of the three mean and how Charles Darwin combined the ideas of each into his concept of evolution. Then write your team's understanding of the theory in your own words.

Participation Activity

In the little envelope in your "source packet" is a series of circles of different colors. While one team member closes his/her eyes, scatter the circles on the desk top. Next tell the "blind" member (who represents a predator) that he/she should pick up as many circles (which represent prey) as possible in 15 seconds. After this is done, count the different number of colors "captured by the predator." Write the results on a team sheet and explain how this relates to natural selection.

Even though we seem to have a large variety of tastes, we have only four types of receptors for gustation. The receptors are located in different regions of our tongue. Each member of your team should apply one of the solutions at your teamsite to his/her tongue and determine where he/she senses a definite taste. Note where the sense occurs on the tongue and what it tastes like. Draw a team map of taste locations on the tongue.

Figure 1. Examples of the constructivist-based biology activities that work with cooperative learning.

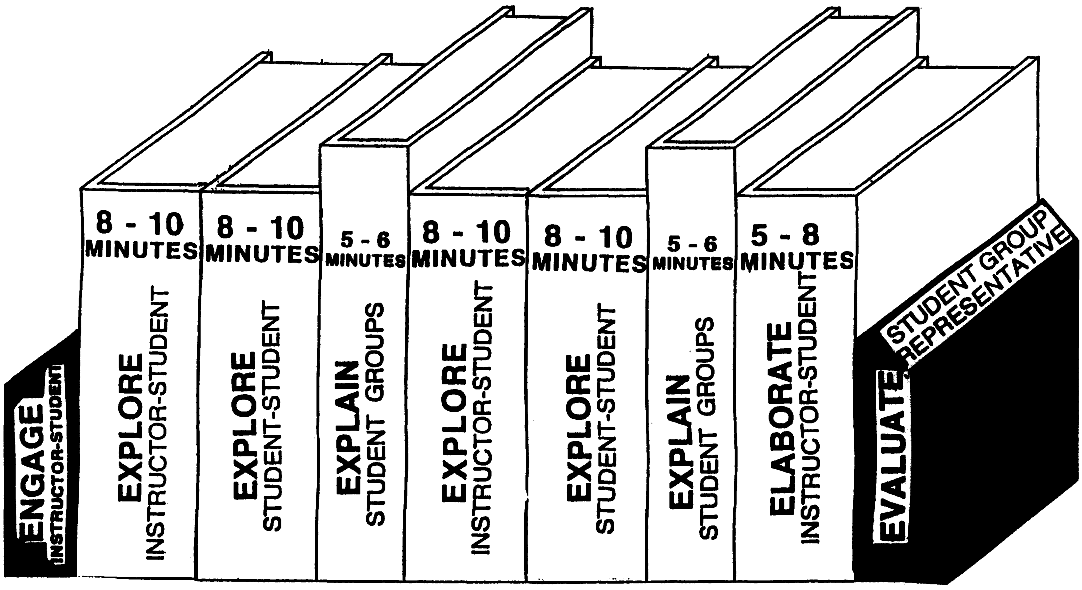

Figure 2. The bookshelf approach to using the "5 E" model during a 60-minute period. Teacher-student exploratory sessions are interspersed with student-student activities during instruction.

answer on the answer sheet. Answer sheets are collected by the instructor as each team completes the question. Next, the teacher randomly selects one or two answer sheets from the collected bunch and asks one of the team members to recite his/her group's answers. Correct and incorrect conclusions are discussed as a class and corrections are suggested by teams when needed. Following this event, the instructor moves the class toward further elaboration of the material and another group challenge.

The above sequence is repeated several times during the class period as learning extends further and further into the topic of the day. The system can be thought of as a series of informative books placed in a progressive sequence on a bookshelf. As students move through the class, they pick up new information to 10- to 12-minute spurts broken by short periods of student-to-student interaction in which each pupil tests the fit of his/her perception of what was just discussed with his/her own knowledge about the subject (Figure 2).

With 8 to 10 minutes left in the class, the teacher directs the groups to conclude what they have learned and gives them several minutes to review the information with one another. Then, with five minutes to go, a color or number is randomly selected from a series of four (each group member has his/her own color or number). When a color or number is selected, the person holding that color or number takes a short quiz on the day's material and the rest of the class is excused. All members of the team receive the grade earned by their representative. Alternatively, if it is not possible to excuse the nontest-takers, each member of a team can take the quiz. In this situation, the instructor will randomly select only one test from the group to count for each team member. Because the students do not know which member will be selected, they all study and review for the test. In this way all of the team members are accountable for the information.

Sharing & Grading in Cooperative Learning

Another of the concerns expressed about using cooperative groups was how teachers could be sure that the work is being shared equally within the group rather than being done by one or two in the team. The answer is that it is impossible to know this. However, if one thinks about the work each individual in a society performs in the "real world," he or she realizes that work is rarely shared equally by each member of the population. Some societal members contribute more than others to the community. However, if everyone does what he or she can, the whole community benefits. Recognizing only the best people in a community is rarely productive since it turns many would-be supporters or contributors away. In fact, rewarding specific individuals in a community is really only important in highly competitive situations. With cooperative learning, the goal is sharing the task of learning and helping each person through the activity. Because the students in each team all begin with different levels of preexisting knowledge, they all build their new insights of the information on different cognitive foundation levels. Therefore, some students need more help than other students to understand the material. Through teamwork, everyone benefits and all learn from the experience. The brightest student in the group tends to contribute more to the concluding answer than the others in the team but, if it is a good cooperative learning activity, all members in the group will be involved and all will learn from the activity! By explaining it to others, the bright student tests his/her understanding of the item, often discovering and correcting perturbations in his/her thinking. This results in a clearer understanding of the subject by that student. Other students in the group also learn as they attempt to make sense of the new information from their cognitive bases. These students often interject issues pertinent to the subject that the brighter student hasn't considered. In so doing, the poorer student gains the respect of the others in the group, something that generally doesn't occur in teacher-directed classes. The students in the middle also benefit as they contribute and analyze the issue, fitting it with their preconceived thoughts.

Grading is always a difficult problem with student-centered classes. It is often hard to determine where each student falls on a conventional percentage scale when groups, rather than individuals, receive scores for work. One way to avoid this dilemma is to base student grades on points earned rather than

- Divide your class randomly into teams during *the first meeting*.
  a. Seat numbers on syllabus—seating chart on overhead.
  b. Group letters on syllabus—group letters taped on wall.
- Tell students what you're doing in the first class.
- Give students an activity to do early in first class to try it out.
  a. Give at least one to two team activities *each period*.
  b. Make team activities *challenging*.
  c. Center team activities around *constructivist principles*.
  d. Always give the groups *a number of answers* to shoot for.
- Use *points rather than grades* (i.e. 1000 possible for class).
  a. Give student points for *quizzes, tests, labs, team sheets*.
- Give students credit for group work *only if they are present*.
- Place *all materials* the groups will use in a large envelope (content packet).
  a. Group member retrieves the envelope when class starts.
  b. Group member returns the envelope when class ends.
- Provide groups with a *single outline* of material for the day in the content packet.
- Keep *each member* of the group apprised of his/her status.
  a. Put individual's points in content envelope each meeting.
- Give a short quiz at end of *each class* for accountability.
  a. Give teams 3–5 minutes to straighten out member problems.
  b. Randomly select one member of each team to take quiz.
  c. All present members get points earned by team quiz-taker.
- Set it up so everyone in the class can attain *quiz point maximum*.
  a. i.e. Must earn 150 quiz points by semester's end.
  b. Manipulate quiz points as needed (5 points/quiz early, 8 points/quiz later).
  c. Go over the session quiz at the onset of the next meeting.
- Give major exams to each student—not to a team test-taker.

Figure 3. Managing a constructivist-based, cooperative learning class.

percentage scores throughout the marking period. Students can earn points toward their grade both through their contribution to the team (i.e. group answers on challenge questions, group tests and quizzes, group homework, group projects, group papers) and through assessing their understanding as individuals (i.e. individual exam scores, individual project contributions, topic contributions to a term paper). The instructors can decide how much of the final grade should be based on points earned through group or individual efforts (Figure 3).

Sometimes a single cooperative group activity may carry with it both team and individual assessments. Team projects, debates, term papers, and presentations can be scored both as one unit and/or individually, especially if the assignment includes a specific component for each team member to complete. This type of exercise provides the instructor with a measure of each person's contribution to the group effort (and, therefore, how accountable each member was for the information). Teams receive one score for their project along with an individual member score for his/her contribution. Instructors can weigh the two scores differently as their conscience guides them. For example, each semester student teams in my Environmental Science course prepare a term paper on a major environmental issue (i.e. fossil fuels). The paper always includes four aspects (i.e. biotic impact, abiotic impact, economic impact and social impact), with each member of the group responsible for one of the portions. Students receive 100 points for the overall paper and each receives 100 points for his/her section of the assignment. This system encourages each member of a team not only to do his/her section of the paper but to motivate and help the less capable teammates. If one of the group members defiantly fails to contribute to the project (or provides a half-hearted effort to it), the team's points are determined without the negligent student's contribution. The neglectful student does not receive the points awarded to the team and the team is not penalized for that member's lack of effort.

Conclusion

Biology students need to be actively challenged by their learning. Students don't learn by being passive bystanders in the learning process. The challenge to biology teachers isn't to put together entertaining presentations; it's putting together challenging scenarios and questions that cause pupils to think about what they are being taught. Not only do students need time to think about the challenge but they should be provided with time to discuss their thoughts and ideas with others in their classes. It is through such discussion with peers that students test their new knowledge and correct their misinterpretations. As this occurs, the new information is fitted with their pre-existing insights. This is how knowledge grows in our minds and is what good biology instruction is all about.

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