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Operationalizing Interactive Learning Paradigms Through Cooperative Learning Activities 100% of the Time in Math Classes

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An interesting hypothesis arises during discussions on teaching techniques used in mathematics classes when teachers compare lecturing versus cooperative learning. Some people postulate that it is necessary to present information to students before they attempt to understand it themselves. I believe this supposition clearly articulates the difference between the two paradigms. Cooperative learning sets very high expectations, that the students can understand the content by taking responsibility for their learning, versus the instructor assuming she/he must cover the material for the students first. In the processes described below, cooperative learning is used 100% of the time in class, thus establishing that the students can indeed learn mathematics with minimal intervention from the instructor. Students rise to the occasion and often exceed their own expectations when they work cooperatively with their peers.

Lecturers maintain that students initially must see a presentation of content material from the professor before they start the process of internalizing the concepts. They claim that students have to see examples of someone working out math problems or constructing computer programs or even solving word problems to begin to understand the underlying concepts. The presentation doesn't have to be long, but it must be there. For students who are good enough to learn the rudiments from textbooks the presentation step can be skipped, they maintain, but most students need a live presentation. Math is something that is better presented live because the students will be able to see the stages of a derivation much better than can be presented in a book.

The argument made above is a common assumption made by many teachers today. The following description of my class procedures, using cooperative learning, is intended to demonstrate that lecturing in math classes is not necessary. Instead a process is used which facilitates student learning by encouraging them to try to understand the material on their own, first by reading the text and then by working out problems together with their peers, finally with the teacher intervening only when absolutely necessary.

In order to set the tone of the class I send my students a letter prior to the beginning of the semester which includes a humorous introduction to the class and cooperative learning, a course syllabus, and a writing assignment in the form of a math autobiography. Students are asked to read the first chapter and start working on the text problems. The first chapter includes review materials from the prerequisite course. My intent is to emphasize their responsibility in the learning process well before the class starts and to demonstrate my own interest in helping them become independent math learners while providing a strong and varied support system in and out of class.

Students are asked to read the text before class and are provided with a class syllabus specifying exactly which sections they are responsible for on a given day. This may be revised during the semester as the class progresses. Students are also asked to complete as many problems as possible prior to class. (They have student manuals which provide worked out solutions for all the odd problems in addition to the text examples). About half the members of each class actually do the work prior to class.

At the beginning of class, worksheets are handed out which contain problems or questions which cover the day's content. No lecture is given until after the work is completed and then only if absolutely necessary. The problems progress from simpler problems to more complex. The students work in pairs or larger groups, usually with 4 people to a table. Sometimes problems are worked out on the board by students who explain and defend their solutions to the whole class, or stu-

dents work directly out of the text together. We have a workbook form of text in the math classes which encourages students to write in the book. By solving problems first in groups, the students are more likely to volunteer to explain their solutions to the whole class. The strategy of starting with the simpler problem is designed to guarantee that students will be able to successfully complete the initial part of each assignment. If they need help, they are encouraged as a group to go back to the text to obtain examples of more complex problems.

I circulate around the class, observing each group's progress and making suggestions about how they might go about finding the answers to their questions. Initially I do not answer questions directly. The students are encouraged to use their text and any other student in the class as resources. Those who did not do the reading and practice beforehand have an opportunity to do so at this early point in the class.

If enough students appear to be having difficulty or generally are making fundamental mistakes, volunteers will be asked to put their solutions on the board to provide a basis for discussion. This might be considered "showing them" what to do, but the advantage is that the explanation comes from the students, not the teacher imposing a solution on them.

The students then go back to work and try to resolve their questions. If they are still confused, I will then facilitate a whole class discussion and try to elicit the source of their confusion. The focus is still on the students, not on me as the person who can solve all their problems and explain everything to their satisfaction.

Group quizzes are often used as a form of review after we have covered several sections within a chapter. First students work individually and then they compare answers and try to reach agreement on the final answer. At this point it becomes clear which students are competent and which are not, and I can encourage those who need extra help to obtain tutoring outside of class. On occasion I have postponed tests because I have observed enough unprepared students to know that a test would be a disaster. Coddling? I do not think so. Sometimes, with all the pressures students are under today, there is a critical mass that just aren't ready to demonstrate their knowledge through a test at a time specified for our convenience. That is not to say that my courses are open ended. They are not, but within a syllabus there is some scheduling flexibility, which is appreciated by the students.

Finally, an in class test is completed individually by each student to maintain their accountability. A mastery approach is used where students have an opportunity to correct their mistakes during the exam, before a final grade is calculated. Here again I walk around the room observing students' progress. When they complete their test, it is checked immediately and any incorrect answers are circled, without indicating what mistake was made. Students then have an opportunity to make corrections. If they get below an 80% after corrections, then they need to take a new test outside of class.

Every step of this process is intended to encourage the students to take responsibility for their learning. This sets very high expectations for the students and myself as the facilitator. My role is to provide materials which will help guide them through the process and work with them to develop appropriate group interaction skills, which are sorely lacking these days. I am intensely involved in each class as I circulate and talk to students individually or in pairs or groups and guide the classes between whole group discussions and individual work.

There are other cooperative processes, such as jig saws, math olympics, make up your own tests, pair reading and writing, group reviews, etc., which are used in addition to the one described above so that the classes never become completely routine. Student responses are that the classes fly by, and they are exhausted at the end of class but feel good about what they have accomplished. By the end of the semester the better students have learned how to become more independent learners, their math phobia has all but disappeared and they actually begin to like math, and the less motivated students have learned more math than they ever expected. In class the students cover more material than I could ever hope to lecture on and obtain their understanding. And, they understand in a way that makes sense to them because they are developing their own solutions.

My classes generally run around 25 students, but I have done this with classes as large as 50 and adult groups of 100 in seminars. Obviously, the larger the

class, the harder it is to personalize it. The above procedure would need to be significantly modified for larger classes through the use of in class TA's and other mechanisms. A class of 500 would be very questionable. CL is not meant as a cure all for economic problems and solutions imposed by administrators. It is well established that smaller classes are better pedagogically.

The procedures described above have evolved over a long period of time through a process of trial and error. It not recommended that new teachers initiate this extensive a cooperative learning system without first participating in training programs and conferences dealing with cooperative learning techniques. It takes time for teachers to develop a comfort level and develop a degree of confidence with cooperative processes. A good approach to incorporating CL in math classes would be to initiate one or two new techniques each semester until a full repertoire of activities is available to chose from.

The Need for Interviews in the Mathematics Classroom

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"God does not care about our mathematical difficulties. He integrates empirically."

--Albert Einstein