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ABSTRACT

In the elementary and secondary school mathematics curriculum in the United States, there is a growing argument for and trend towards the incorporation of cooperative learning as the principal method of instruction. Research on the use of cooperative learning with adult mathematics students is less extensive but does exist. This paper incorporates existing research and some experiences with cooperative learning in workplace and collegiate settings. The paper answers the questions: What is cooperative learning? Why use cooperative learning? What methods can be used? How should the groups be organized? and What problems may arise? (Contains 11 references.) (ASK)

Cooperative Learning: Students Helping Students or Stumbling Through the Dark Together?

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In the elementary and secondary school mathematics curriculum in the United States, there is a growing argument for, and trend towards, the incorporation of cooperative learning as the principal method of instruction. The research base supporting the use of cooperative methods for students age 5 through 18 has grown substantially over the past twenty years and the question of 'Does it work?' has been replaced by that of 'How can we maximize its effectiveness?' Research on the use of cooperative learning with adult mathematics students is less extensive but does exist. This paper incorporates existing research and the author's own experiences with cooperative learning in workplace and collegiate settings.

What is cooperative learning?

Cooperative learning embraces a number of classroom organization styles all of which group students together in learning teams for some, or all, of the instructional time. Slavin et al. (1985:6) describes cooperative learning methods as 'structured, systematic instructional strategies capable of being used at any grade level and in most school subjects.' A description appropriate to adult mathematics classrooms is found in Reynolds et al. (1995:5) which depicts collegiate cooperative learning in the following words:

- a significant amount of the work of the course is done in cooperative groups,
- a positive *esprit de corps* exists within the groups,
- team members share a feeling of mutual responsibility for each other,
- group membership is permanent and stable, and
- group work is included in the evaluation process.

Why use cooperative learning?

Much has been written about the changing educational needs of our industrial society. Paramount among those needs is the requirement that employees be prepared to work together cooperatively, sharing ideas and negotiating compromises when necessary. Traditionally, however, cooperation has been the antithesis of the way that mathematics classrooms functioned. Students worked in isolation, competing against each other for grades. Inherent in that competition was the fact that if I did well, someone else in the class must have done poorly.

From a pedagogical standpoint, Slavin et al. (1985:2) roots the rationale for organizing instruction in cooperative settings in the work of John Dewey who emphasized social aspects of learning and the role of the school in educating students in cooperative democratic living. This idea that all learning takes place in a social context is echoed in the work of later educational psychologists such as Piaget and Vygotsky. The old adage that 'the whole is greater than the sum of its parts' comes

to mind when I think about cooperative learning. Each student brings to the discussion some information which s/he alone possesses and adds it to the collective knowledge base used to solve a problem. Combined, the bits and pieces contributed are likely to be better than any one student would have arrived at individually.

Reynolds et al. (1995:13-14) gives evidence from research that students in classes using cooperative learning can develop a more positive attitude toward themselves and toward mathematics. The feelings of helplessness and past failures can be ameliorated by the liberating experience of being allowed to consult peers while struggling with a mathematics problem. In an analogous situation, perhaps a problem with a personal relationship, it is quite natural to discuss the problem with friends, seek the advise of an experienced person or a counseling professional, reflect upon the accumulated input and make a decision. Yet in a traditional mathematics classroom, students are expected to solve problems alone rather than 'cheat' and ask a colleague for help. Small wonder that many students found school mathematics frustrating and developed test anxiety.

But perhaps the best argument I can make for using cooperative learning methods in my class is that teaching has become more enjoyable for me. Instead of standing behind the safety of my lectern or demonstrating brilliant solutions to problems at the chalkboard (carefully worked out ahead of time), I have the opportunity to observe the students engaged in doing, or at least tackling, mathematics problems. I can listen to their questions, to correct misconceptions, to follow discussions wherever they may lead. Prior to this conference, my family and I traveled around Ireland in our own car stopping where and when we wanted to do so, planning each day's itinerary based on the weather and our whims. By contrast, we took a bus tour for one day and saw what the tour company valued, stopped when and where the bus driver had been instructed to stop, ate at the pre-arranged restaurant. While we may have seen sites which we would have missed traveling independently, the family agreed that we liked our own way better. Teaching in a cooperative setting is like that independent travel. Students visit most of the same sites but they do so on their terms and the itinerary, rather than being preplanned, adjusts to individual tastes and requirements.

What methods can be used to promote cooperative learning?
Cooperative learning does not just 'happen' nor is it used the same way by every instructor. There are several standard methods which have evolved over time and some lend themselves to the mathematics classroom better than others. The method which I use extensively is that of small group discovery. Davidson (Slavin 1985:212-213) describes the method in the following way

> The instructor introduced new material with brief lectures at the beginning of class, during which he posed problems and questions for investigation. For most of the class time, the students worked together cooperatively at the blackboard in four-member groups. The students discussed mathematical concepts, proved theorems, made conjectures, constructed examples and counter-examples, and developed techniques for problem-solving. The instructor provided guidance and support for the small groups.

In my own classroom, I tend to switch back and forth between group work and summarization of 'findings thus far.' This allows all the groups to share progress intermittently and maintains a certain collegiate pace. At my institution we have only 45 contact hours per semester with the expectation that students do two hours of homework for each contact hour. This means that frequently problem exploration must continue between class sessions either with group members or individually. More often than not it is individual, since a substantial number of our students are commuter students with part-time jobs who find it difficult to meet their groups outside the classroom . I continue to struggle this problem. I do suggest that group members exchange phone numbers and e-mail addresses. However many students have no e-mail facilities off campus, so that is not a viable solution right now.

There are other cooperative learning methods which can be useful in the mathematics classroom, although I find them more applicable to pedagogy than andragogy. The first is one called Student Teams Achievement Divisions (STAD). With this method, the teacher presents a lesson, the students meet in teams to master worksheets and are then quizzed on the material. The scores of the students contribute to their teams' standings. A second method, and close cousin to STAD is Teams-Games-Tournament (TGT) in which the students play academic games as representatives of their teams instead of taking quizzes. While I appreciate the contribution of these methods to the *esprit de corps*, I question the appropriateness of the competition which they introduce to an adult classroom. How can they be used? Certainly the cooperative mastery activities would be useful at the point in a unit where skill building takes place. I have used the tournament idea for review. In a twist on a popular US television show, the class plays 'Mathardy.' Two teams select a player to compete for prize money (fake, or course) and the remaining teams must determine the correct answer.

In another cooperative learning method, Learning Together, students work together on a group assignment and individual scores are based on that group product. In the adult mathematics classroom this could be used when students attack a sizable problem, probably a real-life situation, when the problem involves the computer for representation and solution, or when a research project and/or presentation is assigned. Similar methods to Learning Together are Group Investigation and Co-op Co-op. In these methods each cooperative group assumes a specific task and then subtasks within the group. The tasks are usually open-ended investigations using various resource materials. They differ in assessment techniques. Group Investigation reports are evaluated by fellow students and the teacher. In Co-op Co-op, students take individual quizzes on each topic once the reports are completed.

Do not be surprised if the group dynamics in your classroom evolve differently from any of the classic models. In an adult classroom where I implemented cooperative learning, my perception was that group work was not taking place. At the end of the course, however, all the students interviewed cited group work as their favorite characteristic of the course. Upon reflection, I realized that their approach, while different from pedagogical models, functioned well. Rather than jump right in to group discussion, the adult students worked on the assignment alone for a few minutes, tried to solve the problem, and then proceeded to discuss it together.

The above discussion does not pretend to be complete or exhaustive. Readers interested in detailed information on cooperative learning methods should access the texts edited by Slavin and Sharan in the references of this paper.

How should the groups be organized?
There are strong arguments made for heterogeneous grouping of students (Slavin 1985:179, Reynolds 1995: 25). Proponents argue that such groups have a positive effect on both achievement and attitude. In my own work, students have echoed those research findings. The best student in one class said that he benefited from explaining his problem solutions to fellow students. Weaker students said that explanations from classmates aided their understanding and mastery of material. In a very diverse class it may be better to group students in high-to-middle and middle-to-low ability as there may be too much of a gap between the highest and lowest students to render effective cooperation within groups.

Teachers who organize cooperative groups should strive for heterogeneity of other descriptors beside ability. The instructor should include both male and female students in each small group as well as students of different ethnicities. In classes where many students speak English as a second language, efforts should be made to include native and non-native speakers of English in each group. In port-of-entry schools, it might be wise to pair students who are proficient in English with new arrivals when composing the groups. When there is a broad range of ages within the class, traditional age and adult students should be blended together. Many instructors build groups based on a questionnaire completed during the first week of class. The task of achieving heterogeneity seems daunting but one can only consider all the factors and try for a good mix.

Size of groups is another question. Some instructors start the students working together in pairs to become accustomed to cooperating while the teacher is planning larger, permanent groups. Four appears to be a good group size. In situations where attendance is erratic, groups of five or six would guarantee that at least a quorum would be at any one class meeting. In groups larger than four, effective dialogue seems to decrease as there is less opportunity to speak and physical distance between students require shouting to be heard or separate discussions with immediate neighbors, which fractures the group structure.

Finally, should the groups self-select? There is no right answer to this question. Sometimes you will have no choice. In a workplace situation where you are one of several instructors, students might be ensconced in a seat and refuse to budge from it. Perhaps you only want to use groups for initial problem exploration. Self-selection would be fine in that case. If, however, you hope for a good degree of heterogeneity, instructor direction really is needed to achieve it.

What problems may arise?
For starters, adult students know how a mathematics classroom should operate, and cooperation is not part of that experience. Resistance to group work can range anywhere from initial discomfort in consulting with peers to outright rebellion voiced as 'I paid good money for her to teach, not to listen to some other student tell me what to do.' It has been my experience that most students

overcame their initial suspicion and enjoyed the opportunity to discuss questions before a small audience of peers. There have been one or two exceptions and I must confess that I do not force adult students to join a group if they adamantly refuse to do so. As an adult educator I do not see my primary function to be a molder of personality and therefore allow students to be a 'group of one' if they so choose.

Even adults need direction in working cooperatively. The teacher needs to establish some basic ground rules for how the groups should operate. Conflict is a natural outcome of open discussion and instructor intervention can range anywhere from a few soothing words in class to private sessions with group members or, in the worst case, reorganization of the groups. Many instructors who use cooperative learning devote the first few classes to activities which build cooperative skills and enhance group dependency. During that period, discussion of conflict resolution strategies can be aired before, rather than after, conflicts arise.

The physical layout of the classroom can present challenges to cooperative learning. A classroom with small table which seat four to six people is a good setting for cooperation. Furniture which can be rearranged into groups is a good alternative, but time is lost at both ends of the class session when desks get moved. Seating at both tables and grouped desks can distract students if you alternate between small-group and whole-group work throughout the class since the physical closeness facilitates private conversation when you are trying to centralize discussion.

Simpson (1995) points out that competition between groups can become an issue. In the pursuit of the elusive 'outstanding' grade, groups may downplay the work of others or try to outdo each other in presenting their own solutions. In institutions which limit the number of 'A' (4.0 or outstanding) grades which a teacher can give, this presents a real problem. The traditional class pits student against student in an intrinsically competitive environment. If cooperation is to work, students must be confident that they will all benefit from the success of each individual.

This leads to one last point, that of assessment. Students know that it is 'the test' that really matters. If instruction is to stress cooperative problem exploration and group solutions and then all assessment tools test the students individually, cooperation will have a short lifespan. There are several ways to assess cooperative work. The most dramatic method bases the grade of all individual students on the group product. All students sign off on the work and submit one solution, quiz, or test. This is rather utopian. A more common approach bases a percentage of the student grade on the group product and then test individually for the rest of the grade. A third approach assesses specific products collectively and others individually. For example, quizzes or tests during the semester might be group work but the midterm and exam are taken, and graded, on an individual basis.

Summary
Cooperative learning is one of many practical ways to organize the adult mathematics classroom. It requires planning and tactfulness on the part of the instructor if it is to work. Many students and instructors in cooperative classrooms feel that it is both an effective and enjoyable way to learn mathematics. Having made a commitment to cooperative rather than competitive learning, I cannot imagine myself returning to the traditional lecture format with which I began my teaching career.

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