The Craft Of Teaching
Cooperative Learning: An Active Learning Strategy

Karl A. Smith
Civil and Mineral Engineering
University of Minnesota
Minneapolis, Minnesota

How do you learn best? What conditions, environment, circumstances, etc. make is easiest for you to learn? Please reflect for a moment. I have asked this question of thousands of faculty around the world. Usually I ask it in an informal cooperative learning format: **Formulate** an answer individually, **Share** your answer with a partner, **Listen** carefully to your partner's answer, and **Create** a new answer through discussion (or, my favorite, **Learn** your partner's response well enough to present it if you're called on). Typical responses include: "I learn best when it's something I'm interested in," "When I'm motivated to learn either through interest or need," "Through reading on my own and making notes," "Through expressing it in my own words, such as by writing a summary," "Through explaining it to someone else," "Through preparing to teach," "By doing it." My surveys indicate that faculty prefer to learn in a variety of ways, most of them active. Very few faculty have said, "I learn best by listening to a lecture."

Who learns the most in the typical college classroom? Who is organizing, summarizing, and presenting? Who is elaborating, and providing rationale and justification? In other words, Who is actively involved? Who is having the most fun in the typical college classroom? Perhaps no one. Most likely, however, the professor is learning the most and having the most fun!

My work and this short paper focus on ways to involve students in learning, thereby distributing some of the responsibility and some of the fun of learning.

Active student involvement is often specified as a necessary condition to turning around the passive, formal lecture approach used in most college classrooms. Astin (1985, 1987, 1988), developer of the talent development model of excellence advocates that getting students actively involved cognitively, physically and emotionally is the key to developing talent. Eric Block (1987), Director of the National Science Foundation, summarized the importance of developing talent as follows: "Our people--with their creativity, skills, and education--are our most important resource...We simply cannot afford to waste their talent." McKeachie, et al. (1986) states that the next best answer (after "It depends") to the question "What is the most effective method of teaching? is 'Students teaching other students.' There is a wealth of evidence that students teaching other students is extremely effective over a wide range of content, goals, students and personalities."

Numerous reports have presented similar conclusions. The missing ingredient is how to do it, that is, how to get students meaningfully involved in the classroom.

Cooperative learning is one very effective answer to this question. A conceptual approach to cooperative learning has been developed by David and Roger Johnson at the University of Minnesota. Their approach is characterized by five basic elements:

Positive Interdependence exists when students believe that they are linked with others in a way that one cannot succeed unless the other members of the group succeed (and vice versa). In other words, students must perceive that they "sink or swim together." In a problem-solving session, positive interdependence is structured by group members (1) agreeing on the answer and solution strategies for each problem (goal interdependence) and (2) fulfilling assigned role responsibilities (role interdependence). Other ways of structuring positive interdependence include having common rewards, being dependent on each other's resources, or a division of labor.

Face-to-Face Promotive Interaction exists among students when students orally explain to each other how to solve problems, discuss with each other the nature of the concepts and strategies being learned, teach their knowledge to classmates, and explain to each other the connections between present and past learning. This face-to-face interaction is promotive in the sense that students help, assist, encourage, and support each other's efforts to learn.

Individual Accountability/Personal Responsibility requires the teacher to ensure that the performance of each individual student is assessed and the results given back to the group and the individual. It is important that the group knows who needs more assistance in completing the assignment and it is important that group members know they cannot "hitch-hike" on the work of others. Common ways to structure individual accountability include giving an individual exam to each student, randomly calling on individual students to present their group's answer, and giving an individual oral exam while monitoring group work.

Collaborative Skills are necessary for effective group functioning. Students must have and use the needed leadership, decision-making, trust-building, communication, and conflict-management skills. These skills have to be taught just as purposefully and precisely as academic skills. Many students have never worked cooperatively in learning situations and, therefore, lack the needed social skills for doing so.

Group Processing involves a group discussion of how well they are achieving their goals and how well they are maintaining effective working relationships among members. At the end of their working period the groups process their functioning by answering two questions: (1) What is something each member did that was helpful for the group and (2) What is something each member could do to make the group even better tomorrow? Such processing enables learning groups to focus on group maintenance, facilitates the learning of collaborative skills, ensures that members receive feedback on their participation, and reminds students to practice collaborative skills consistently.

Although there is abundant support for cooperative learning, there are very few formal and systematic strategies for implementing the approach in the college classroom. Our work has focussed on applying the research and development of each of the strategies to the college classroom. We are integrating and relating the cognitive research on how students learn, the research on the importance of social support, the research on the importance of collaborative skills, and the research on the importance of active involvement to the cooperative learning strategies mentioned above.

Types of Cooperative Learning

In order to maximize their achievement, especially when studying conceptually complex and content-dense materials, students should not be allowed to be passive while they are learning. One way to get students more actively involved in this process is to structure cooperative interaction into classes so that students have to explain what they are learning to each other, learn each other's point of view, give and receive support from classmates, and help each other dig below the superficial level of understanding of the material they are learning. It is vital for students to have peer support and to be active learners, not only so that more students learn the material, but so that they get to know other students in class and build a sense of community that centers on the academic side of the school. It is equally important that when seniors graduate they have developed skills in talking through material with peers, listening with real skill, knowing how to build trust in a working relationship, and providing leadership to group efforts. Without developing and practicing the social skills required to work cooperatively with others, how can faculty honestly claim that they have prepared students for a world where they will need to coordinate their efforts with others on the job, skillfully keep a marriage and family functioning, and be a contributing member of a community and society?

Cooperative learning may be incorporated into courses through the use of: **informal learning groups**; which are short-term and less structured; **formal learning groups**, which are more structured and stay together until the task is done; and **base groups**, which are long-term groups whose primary role is one of peer support and long-term accountability.

Informal cooperative learning groups can be used in a variety of ways at any time in any size class. Three ways they can be used in a lecture class are: (1) to focus the students prior to the lecture, (2) to break up the lecture and provide the students a chance to review and check for understanding, and (3) to summarize the main points at the end of the lecture. Each of these three uses of informal groups can be initiated by asking the student to turn to the person next to them and discuss their response to the question.

The longer term **formal cooperative learning group** is put together to do a specific job such as review homework, work through a problem together, review for a test, perform a lab experiment and write a report, or conduct a design project.

Formal cooperative learning groups are used in all my engineering classes. Students are given a problem to formulate and solve or material to be mastered. Students then work in small cooperative groups to formulate and solve the problem or frame a concept. They prepare a report (either on paper or on overhead transparency) describing how the problem was formulated and solved or how the concept was represented and how it relates to other concepts. Later, a representative from each group is randomly selected to present the group's solution, representation or summary. The representations or the approaches used by the various groups to solve the problem are compared and discussed by the whole class. Finally, each group is provided time for processing its effectiveness.

Another application of formal work groups is the use of structured controversy in environmental issues seminars taught by Karl Smith and Roger Johnson. These seminars focus on content acquisition and on helping students develop collaborative skills (through cooperative group learning), constructive conflict management skills (through structured controversy discussion), and perspective-taking skills (through presentation and discussion of different perspectives on each issue). In a structured controversy students are assigned a position on an issue which they prepare, present and defend. The goal is to understand the best arguments on all sides of the issue, but the students are stimulated to prepare better arguments when they are confronted with a compelling argument from the other side. The structured controversy technique is described in Johnson, Johnson and Smith (1986), Smith (1984).

Base groups are long term groups with stable membership whose primary responsibility is to provide support, encouragement, and assistance in completing assignments. Base groups not only tend to improve attendance, they also are given the task of letting group members know what went on in class when they have missed a session. The larger the class and the more complex the subject matter, the more important it is to have base groups.

Details of informal, formal and base groups as well as additional information on cooperative learning are available in Johnson and Johnson (1987), Johnson, Johnson and Holubec (1986), Smith (1985, 1987, 1988), and Smith, Johnson and Johnson (1981). Examples of instructional materials for use in this active learning mode are available in the book How to model it (Starfield, Smith and Bleloch, 1990). This book is an attempt to represent how we teach. We have embodied three principles for learning how to think described by McKeachie (1988): (1) bringing order out of chaos, (2) discovering uncovered ideas, and (3) developing

strategies, while avoiding jumping to conclusions.

The cooperative learning strategies outlined above are consistent with the seven principles for good practice in undergraduate education compiled in a study supported by the American Association of Higher Education, the Education Commission of the States, and the Johnson Foundation (Chickering and Gamson, 1987). **Good practice in undergraduate education:**

1. Encourages student-faculty contact.
2. Encourages cooperation among students.
3. Encourages active learning.
4. Gives prompt feedback.
5. Emphasizes time on task.
6. Communicates high expectations.
7. Respects diverse talents and ways of learning.

Research Support

The research support for cooperative learning is extensive and growing. A recent meta-analysis revealed 137 studies of cooperative learning at the college level (Johnson and Johnson, 1989). This analysis concluded that (1) productivity will tend to increase as members do in fact gain increased expertise, (2) committed and positive relationships will tend to develop among members, (3) social support will tend to increase, and (4) professional self-esteem will tend to be enhanced.

Research conducted by Schoenfeld (1985, 1989); Brown, Collins and Dugin (1988); Lave (1988); and others shows the importance of getting students involved in meaningful activities in the classroom, and the importance of peer interaction and situated cognition. Recent theoretical and empirical support for peer response groups in the writing classroom also corroborates these conclusions (DiPardo and Freedman, 1988).

McKeachie (1988) concludes that at least three elements of teaching make a difference in students' gains in thinking skills: (1) student discussion, (2) explicit emphasis on problem-solving procedures and methods using varied examples, and (3) verbalization of methods and strategies to encourage development of metacognition. He states, "Student participation, teacher encouragement, and student-to-student interaction positively relate to improved critical thinking. These three activities confirm other research and theory stressing the importance of active practice, motivation, and feedback in thinking skills as well as other skills. This confirms that discussions, especially in small classes, are superior to lectures in improving thinking and problem solving."

Greeno's (1989) summary of general thinking skills revealed three framing assumptions that may be impeding our ability to develop a more adequate theory of thinking. They are: (1) the locus of thinking is assumed to be in an individual's mind, rather than in interaction between an agent and a physical and social situation, (2) processes of thinking and learning are assumed to be uniform across persons and situations, and (3) resources for thinking are assumed to be knowledge and skills that are built up from simple components, especially through instruction in school, rather than general conceptual capabilities that children may have as a result of their everyday experience. Greeno stresses that a different set of framing assumptions may be needed if we are to make significant headway toward an adequate understanding of thinking and creativity. The three assumptions that he proposes are the following:

1. **Situated cognition.** Thinking is situated in physical and social contexts. Cognition, including thinking, knowing, and learning, can be considered as a relation involving an agent in a situation, rather than as an activity in an individual's mind.

2. **Personal and social epistemologies.** Thinking and learning are situated in contexts of beliefs and understandings about cognition that differ between individuals and social groups, and fundamental properties of thinking and learning are determined by these contexts.

3. **Conceptual competence.** Children have strong potential capabilities for cognitive growth that enable complex and subtle processes of construction of knowledge and thinking skills. Thinking, learning, and cognitive growth are activities in which children elaborate and reorganize their knowledge and understanding, rather than simply applying and acquiring cognitive structures and procedures.

Importance of Cooperative Learning

I try to follow Wilbert McKeachie's advice on lecturing: "I lecture only when I'm convinced it will do more good than harm." While conducting a workshop on cooperative learning for faculty and students at the Norwegian Institute of Technology, I was convinced that a short lecture (given in the informal cooperative learning format) on the latest research on learning would be very useful and effective. I asked a focus question at the start, lectured for about 12 minutes, and asked the participants to prepare a summary of the main points and to formulate at least one question. When I finished the short lecture, and asked for a summary, people didn't know what to write. One student jokingly asked, "Karl, what did you say between 'Here's the research' and 'your task is to create a summary?'"

He got a big laugh, but when we took a break, several of the faculty came to me and said, "I didn't know what you were talking about. The concepts were somewhat new to me, you were enthusiastic and spoke slowly and clearly, but I really didn't understand what you were talking about."

After the break, I apologized to the group for wasting their time. It was painful for me since I thought I had given an excellent lecture. A couple of faculty came to my defense. They said, "Well, you know, it was a pretty good lecture. It was just kind of new to us."

But then a student in the back said, "I understood a little at the beginning, but a lot of lectures are like this for me."

And a student in the front said (with emphasis), "This is what it's like for me every day."

The look on the faces of those faculty! I wish I would have taken a photograph. For the first time in a long time, I think they understood what it's like to be a student out there, trying to make sense out of these lectures, and not understanding, and being frustrated with not understanding.

This is what it's like for many students in college.

Cooperative learning procedures have several important contributions to make to college education. The use of cooperative learning groups approximates more closely the activity of real-world employment and problem solving; allows students to tackle larger, more complicated, and often more interesting problems without feeling overwhelmed; allows students to serve as resources for each other, hence taking some of the pressure off instructors and teaching assistants; and allows students to expend more effort on sharing ideas and on producing high quality products, and less on beating other students on performance measures.

Knowledge and skill are of little use if a student cannot apply them in cooperative interaction with other people. It does no good to train an engineer who does not have the competencies needed to apply knowledge and technical skills in cooperative relationships on the job, in the family and community, and with friends. The most logical way to emphasize cooperative competencies as learning outcomes is to structure the majority of academic learning situations cooperatively.

One of the finest summaries of the basic skills needed to be an effective citizen in our democracy now, at the end of the twentieth century, was written by Herbert Kohl (1982). The skills arise from the technological and social conditions of our time but are based on the fundamental moral ideas of democracy. According to Kohl there are at least six basic skills that our children must acquire if they are to learn how to function effectively and compassionately as adults. They are: (1) The ability to use language well and thoughtfully, (2) The ability to think through a problem and experiment with solutions, (3) The ability to understand scientific and technological ideas and to use tools, (4) The ability to use imagination and participate in and appreciate different forms of personal and group expression, (5) The ability to understand how people function in groups and to apply that knowledge to group problems in one's own life, and (6) The ability to know how to learn something yourself and to have the skills and confidence to be a learner all your life.

Conclusions

Traditional instruction in college is content-based and often follows the normative professional curriculum: teach the relevant basic science, teach the relevant applied science, and allow for a practicum to connect the science to actual practice. As a result, attention is focused on students' mastery of declarative subject matter within narrow domains. This content theory of knowledge is inadequate for preparing students for professional practice in engineering (and in other disciplines, such as medicine and law, as well). Procedural knowledge or "how-to-do-it" knowledge is essential.

Impetus for change is coming from several research fronts: professional expertise (Schon), school versus out-of-school knowledge and activity (Resnick), cognitive apprenticeship (Collins), active learning (Smith, Johnson & Johnson) and the role of calculators, computers, and related technology (Steen, Ralston). As an example of the momentum being generated by this push to revitalize professional curricula, Harvard medical school recently implemented a problem-based curriculum similar to the one introduced at McMaster in 1968 (Abrahamson, 1987). In the McMaster model, students meet in small "tutorials" and consider problems that they cannot solve without acquiring, and thus learning, new information and skills.

Our most important objective is to develop students' motivation and skills for continued learning, problem solving and application of course material after the course is over. Implementing cooperative learning in the college classroom would assist in getting students meaningfully involved in learning and focussing attention on active learning to help prepare self-directed, autonomous learners.

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References

Abrahamson, S. (1987). Harvard medical school tries a problem-based curriculum. The Chronicle of Higher Education, October 21, B1-B2.

Astin, A. (1985). Achieving educational excellence. San Francisco: Jossey-Bass.

Astin, A. (1985). Involvement: The cornerstone of excellence. Change, 17(4), 35-39.

Astin, A. (1987). Competition or cooperation? Teaching teamwork as a basic skill. Change, 19(5), 12-19.

Astin, A. (1988). The implicit curriculum: What are we really teaching our undergraduates? Liberal Education, 74(1), 6-10.

Block, E. (1987). NSF's budget and economic competitiveness. Science, 235, 621.

Brown, J.S., Collins, A., & Duguid, P. (1988). Cognitive apprenticeship, situated cognition and social interaction. Institute for Research on Learning Report No. IRL88-0008. Bolt Beranek and Newman Research Report 6886.

Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18 (1), 32-42.

Chickering, A.W. & Gamson, Z.F. (1987). Seven principles for good practice in undergraduate education. The Wingspread Journal, 9 (2).

Collins, A., Brown, J. S. & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics. In L. B. Resnick (Ed.) Knowing and learning: Issues for a cognitive science of

instruction. Hillsdale, NJ: Lawrence Erlbaum, in press.

DiPardo, A. & Freedman, S.W. (1988). Peer response groups in the writing classroom: Theoretic foundations and new directions. Review of Educational Research, 58 (2), 119-150.

Greeno, J. (1989). A perspective on thinking. American Psychologist, 44 (2), 134-141.

Johnson, D.W. and Johnson, R.T. (1987). Learning together and alone. Englewood Cliffs, NJ: Prentice-Hall.

Johnson, D.W. and Johnson, R.T. (1989). Cooperation and competition: Theory and research. Edina, MN: Interaction Books.

Johnson, D.W., Johnson, R.T., and Holubec, E. (1986). Circles of learning: Cooperation in the classroom. Edina, MN: Interaction Books.

Johnson, D.W., Johnson, R.T., and Smith, K.A. (1988). Active learning strategies for the college classroom: Cooperative interaction. Unpublished manuscript, University of Minnesota.

Johnson, D.W., Johnson, R.T. and Smith, K.A. (1986). Academic conflict among students: Controversy and learning. In Feldman, R. (Ed.) Social psychological applications to education. Cambridge University Press, 199-231.

Kohl, H. (1982). Basic Skills. New York: Little, Brown.

Lave, J. (1988). Cognition in practice: Mind, mathematics and culture in everyday life. Cambridge: Cambridge University Press.

McKeachie, W.J., Pintrich, P.R., Lin, Y-G., Smith, D.A.F. (1986). Teaching and learning in the college classroom: A review of the research literature. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning (NCRIPTAL), University of Michigan.

McKeachie, W.J. (1988). Teaching thinking. NCRIPTAL Update, 1 (2), 1.

Ralston, A. (1987). Let them use calculators. Technology Review, 90 (6), 30-31.

Resnick, L. (1988). Learning in school and out. Educational Researcher, 13-20.

Schoenfeld, A. H. (1985). Mathematical problem solving. Orlando, Academic Press.

Schoenfeld, A.H. (1989). Ideas in the air: Speculations on small group learning, peer interactions, cognitive apprenticeship, quasi-Vygotskean notions of internalization, creativity, problem solving, and mathematical practice. International Journal of Educational Research, In Press.

Schon, D.A. (1983). The reflective practitioner: How professionals think in action. New York: Basic Books.

Schon, D. A. (1987). Educating the reflective practitioner. San Francisco: Jossey-Bass.

Smith, K.A. (1984). Structured controversy. Engineering Education, 74(5), 306-309.

Smith, K.A. (1985). Cooperative Learning Groups, In S. Schomberg, (Ed.) Strategies for active teaching and learning in university classrooms, Minneapolis: University of Minnesota, 18-26.

Smith, K. A. (1987). Educational engineering: Heuristics for improving learning effectiveness and efficiency. Engineering Education, 77, (5), 274-279. Reprinted in The International Journal of Applied Engineering Education, 3(4), 1987.

Smith, K.A. (1988). The nature and development of engineering expertise. European Journal of Engineering Education, 13(3), 317-330.

Smith, K.A., Johnson, D.W. and Johnson, R.T. (1981). Structuring learning to meet the goals of engineering education. Engineering Education, 72(3), 221-226.

Starfield, A.M., Smith, K.A., & Bleloch, A.L. (1990). How to model it: Problem solving for the computer age. New York: McGraw-Hill.

Steen, L.A. (1987). Mathematics education: A predictor of scientific competitiveness. Science, 237, 251-237.

Steen, L.A. (1987). Who still does math with paper and pencil? The Chronicle of Higher Education, October 14, 48A.