DOCUMENT RESUME

ED 472 334 SE 065 652

AUTHOR	Cooper, James; Robinson, Pamela
TITLE	Small-Group Instruction: An Annotated Bibliography of Science, Mathematics, Engineering and Technology Resources in Higher Education, 1997. Occasional Paper.
INSTITUTION	National Inst. for Science Education, Madison, WI.
SPONS AGENCY	National Science Foundation, Arlington, VA.
REPORT NO	NISE-OP-6
PUB DATE	1997-12-00
NOTE	46p.; Preliminary work was supported by the Los Angeles Collaborative for Teacher Excellence, California State University, Dominguez Hills. A draft version appeared in the Mathematical Association of America's MAA Notes (#44).
CONTRACT	RED-9452971
AVAILABLE FROM	National Institute for Science Education, University of Wisconsin-Madison, 1025 W. Johnson Street, Madison, WI 53706. Tel: 608-263-9250; Fax: 608-262-7428; e-mail: niseinfo@macc.wisc.edu. For full text: http://www.wcer.wisc.edu/ nise/Publications.
PUB TYPE	Reference Materials - Bibliographies (131)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	*Cooperative Learning; Engineering Education; Higher Education; Mathematics Education; Science Education; *Small Group Instruction; *Teaching Methods; Technology

ABSTRACT

This bibliography was designed specifically for faculty members or administrators involved in science, mathematics, engineering, and/or technology (SMET) interested in teaching and learning issues. Specifically, it addresses research, theory and/or practice in small groups, and cooperative instruction focusing on SMET disciplines in higher education. Cooperative learning is more structured and teacher-centered than many other forms of small-group teaching. It tends to emphasize formal instructional procedures and focus on individual accountability in course grading. Although this document focuses on cooperative learning, a number of sources addressing other small-group procedures are included since they are of interest to the audience. This document is not an exhaustive description of small- group instruction relating to SMET or the individual disciplines which SMET encompasses but rather the intent is to give readers a snapshot of historical and contemporary work in cooperative learning that furnishes a context from which to view the field. (YDS)

Occassional Paper No. 6

SMALL-GROUP INSTRUCTION: AN ANNOTATED BIBLIOGRAPHY OF SCIENCE, MATHEMATICS, ENGINEERING AND TECHNOLOGY RESOURCES IN HIGHER EDUCATION, 1997

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December 1997

The research reported in this paper was supported by a cooperative agreement between the National Science Foundation and the University of Wisconsin-Madison (Cooperative Agreement No. RED-9452971). At UW-Madison, the National Institute for Science Education is housed in the Wisconsin Center for Education Research and is a collaborative effort of the College of Agricultural and Life Sciences, the School of Education, the College of Engineering, and the College of Letters and Science. The collaborative effort is also joined by the National Center for Improving Science Education, Washington, DC. Any opinions, findings, or conclusions are those of the authors and do not necessarily reflect the view of the supporting agencies.

Preliminary work on this document was supported, in part, Los Angeles Collaborative for Teacher Excellence (LACTE), a National Science Foundation-sponsored consortium project housed at California State University, Dominguez Hills. A draft version of this paper appeared in the Mathematical Association of America's MAA Notes (#44).

INDEX

SMET Resources ***Citation Numbers***

Research/Theory and Applications Numbers in **bold** are especially recommended for *new* practitioners interested in applications of small-group instruction to a specific discipline.

Algebra	54 **88**
Calculus	16 30 53
Statistics	17
Graduate Education	23 24
Sourcebook	77 **82** **85**
Teacher Education	48
Medical/Dental	19 27 47
Physical Therapy	25
Meta-analyses	
SMET	49
Nursing	28 29 **38**
Physics	**31** **32** 87 98
Sourcebook	**90**
Science	33 **44** 52 55 56 78
Laboratory	36
Science for Education	18 45 57
Sourcebook	**84**
Veterinary Medicine	86

General Resources ***Citation Numbers***

Research/Theory and Applications Numbers in **bold** are especially recommended for *new* practitioners interested in applications of small-group instruction.

Applications	58 59 **61** **62** 63 66 71 **72** 73 74 **75** 76
Annotated Bibliographies	12 14
Meta-analyses	7 8
Research/Theory	**1** **2** 3 4 5 6 9 10 11 13

Introduction

In constructing this bibliography we had rather specific readers in mind: faculty members or administrators involved in science, mathematics, engineering and/or technology (SMET) who are interested in teaching and learning issues. Specifically, these persons would be interested in research, theory and/or practice in small-group, cooperative instruction focusing on SMET disciplines in higher education. Cooperative learning is more structured and teacher centered than many other forms of small-group teaching. It tends to emphasize formal instructional procedures (designed to ensure that students feel a sense of positive interdependence) and to focus on individual accountability in course grading (as opposed to undifferentiated grades for all members of a group, regardless of differing individual contributions). Although this document focuses on cooperative learning, a number of sources dealing with other small-group procedures are included since we feel that they are of interest to the readers.

This document is not an exhaustive description of small-group instruction relating to SMET or the individual disciplines which SMET encompasses. Our intent is to give readers a snapshot of historical and contemporary work in cooperative learning that furnishes a context from which to view the field. Readers may choose from a number of resources, depending on interests and needs.

Organizational Plan

We have organized this bibliography into two major sections, one dealing with Research and Theory and the other dealing with Applications. Each of the two major sections is subdivided into two portions, one related to **general** cooperative-learning issues and one that is specifically focused on **SMET**-related cooperative-learning issues.

Our reasoning for including a number of general cooperative-learning resources in this bibliography is that SMET-related research on cooperative learning in higher education is a relatively new and undeveloped area of inquiry. Many of the authors in the SMET sections of this bibliography were influenced by others who have published work dealing with general applications of cooperative and collaborative learning. For readers to have a more complete understanding of small-group instruction in higher education and to help set a context for the SMET-related contributions, a number of significant historical and contemporary general contributions to teaching and learning are included.

Section 1.A. This section in the bibliography addresses **general** cooperative-learning issues dealing with research, theory and practice. The definition of cooperative learning, and how it is similar to and different from other forms of active-learning strategies are among the topics treated. We identify sources documenting the empirical base for cooperative learning and other small-group procedures and place them in a general theoretical setting.

Section 1.B. This section identifies sources which document theoretical and empirical support for the power of cooperative learning as it is used in **SMET** disciplines. Resources are described which assess the impact of cooperative learning on a number of student outcome measures. The majority of these sources have been published in the 1990s.

Section 2.A. This section focuses on **general** applications of cooperative learning to the classroom. There are many types of cooperative learning. Spencer Kagan (Citation 69 in this document) reports that there may be over 100 different forms. The intent of this section is to identify resources which may help readers get a sense of the broad range of structures implemented by practitioners in the field, structures which have been used at all levels of education, with many disciplines and many student populations. Some SMET practitioners may be unaware of the rich variety of techniques available, which are often field-tested by those working with more generic applications of cooperative learning.

Section 2.B. This section, which addresses **SMET**-related applications of cooperative learning, gives readers a sense of the variety of applications of cooperative learning in a number of SMET-related fields.

Guiding Questions

Faculty and administrators often ask the same fundamental questions about cooperative learning. We identify those questions which many readers of this report may also have and suggest specific resources in the bibliography that will address each.

What is cooperative learning and how does it differ from other forms of small-group instruction such as lab groups, study groups, collaborative learning and problem-based learning? Matthews, Cooper, Davidson and Hawkes (9) have written a short piece using non- technical terminology that describes differences between cooperative and collaborative learning. For more detailed treatments of a number of small-group procedures, readers may be interested in an article by Jean MacGregor and Barbara Leigh Smith in the Goodsell et al. book (65) or the detailed taxonomy provided by Joe Cuseo (4). A number of other authors included in this bibliography also address the distinctions between cooperative learning and other forms of small-group and active-learning strategies.

Is there research and theory which supports the use of cooperative learning? Is there supporting research at the college level? In SMET generally? In my discipline? The short answer is that there is considerable evidence that cooperative learning is effective in fostering a number of cognitive, attitudinal and other outcomes. Much of the work has been done at the pre-collegiate level, as documented by the Johnson, Maruyama, Johnson, Nelson, & Skon 1981 meta-analysis (8) and the Johnson & Johnson 1989 research and theory text (7). These two resources also include research performed at the college level, as do Cooper (12) and his associates in three annotated bibliographies published in 1989, 1991 and 1995. Some of the citations from these bibliographies are included in the current annotated bibliography.

The best documentation that cooperative learning is effective in SMET disciplines in higher education can be found in the meta-analysis recently completed for NISE by Leonard Springer, Mary Elizabeth Stanne and Samuel Donovan (49). The NISE group found that SMET classes taught using cooperative learning achieved robust effect sizes (.50) when measuring the impact of cooperative learning on student achievement, student attrition and student attitudes. They have identified an ambitious line of future research which will address questions relating to the impact of cooperative learning on a number of student outcomes, types of students, and disciplinary areas.

Regarding the impact of cooperative learning on specific SMET-disciplinary areas, the college-level research is still relatively new and has yet to be systematically organized. Treisman (53) in mathematics, Felder & Brent (80) and Felder (81) in engineering, Heller & her associates (31,32) in physics and M. Cooper (21, 22) in chemistry have led colleagues within disciplinary groups demonstrating that small-group work can have a powerful impact on achievement, attrition and attitudes among students, particularly women and minorities.

The research and theory section of this bibliography identifies a number of qualitative and quantitative studies which are beginning steps in what we hope will be a long-term commitment by NSF and others to further assess the impact of cooperative learning within and across SMET disciplines, and to organize this information in order to stimulate additional research and applied work. The present authors have recently completed a thematic paper which attempts to assess the current status of small-group instruction in college SMET disciplines and to suggest an agenda for future research and practice.

Where can I find specific information regarding how to implement cooperative learning? I am particularly interested in college-level applications, preferably ones that are specific to my field. There are a number of workbooks that are useful. Spencer Kagan (69) has written an applied text that identifies over 100 cooperative-learning techniques. The book is primarily designed for K-6 personnel though it can be useful to higher-education practitioners. Philip Abrami and his colleagues (58) have written a general sourcebook which is designed for both collegiate and precollegiate audiences and combines a good mix of research, theory and practice. David and Roger Johnson and Karl Smith (67) have written an excellent workbook that is very popular. Designed for college teachers, it focuses on general applications of cooperative learning. Susan Nurrenbern has recently published a useful cooperative-learning workbook (96) specifically designed for chemistry teachers. McNeill and Bellamy (93) have written a very applied workbook describing how cooperative learning can be used in college engineering classes. Hagelgans et al. (82) have constructed a good workbook designed for college-level math teachers. Readers will want to consult the general and the SMET-related applied sections of the bibliography for many additional articles about cooperative learning and college teaching.

For a brief, readable general overview of cooperative learning, the chapter written by Barbara Millis (71) is recommended. In it she identifies a variety of small-group procedures in clear terms and treats assessment and grading issues.

The index for this bibliography identifies sources within specific disciplinary areas. The citations in bold identify resources within each discipline that we believe may be particularly useful for the person new to small-group instruction who is interested in very applied materials.

Conclusion

This collection of resources dealing with cooperative learning in college-level SMET disciplines has been a challenge to assemble. We examined hundreds of documents in selecting the resources to be contained in this publication. As noted earlier, this bibliography is a work in progress that will change and grow as the work in cooperative learning continues to grow. We would like to hear from readers who wish to suggest materials for inclusion in future bibliographies.

Our intent with this document is to give readers a snapshot of the field at a point in time. It is incomplete and not entirely consistent, just as the research, theory and application of cooperative learning in SMET are incomplete and, at times, inconsistent. The work of NISE, NSF, NRC and other groups will ultimately provide more focus for this developing body of knowledge. But we believe that an interim report on the state of cooperative learning in SMET disciplines in higher education may serve to stimulate interest in more work which may bring greater coherence to this very young field.

Section 1. RESEARCH and THEORY

Section 1.A. General Cooperative-Learning Resources.

1. Bouton, C., & Garth, R. (Vol. Eds.) & K. E. Eble, & J. F. Noonan (Series Eds.). (1983). Learning in groups. New directions for teaching and learning, 14. San Francisco: Jossey-Bass.

A text in which a number of different chapter authors describe research and practice in collaborative learning. A good overview concerning how collaborative learning can be applied in a variety of college disciplines. Recommended for the new practitioner, and those already implementing collaborative techniques. The text includes an influential chapter dealing with the Atlas complex by Finkel and Monk. The Atlas complex is thinking that the instructor must take total responsibility for students' success. Finkel and Monk argue that instructors should work collaboratively with students in sharing responsibility for success in the classroom.[1]

2. Chickering, A. W., Gamson, Z. F. (1987). Seven principles for good practice in undergraduate education. AAHE Bulletin, 3-7.

A report published by AAHE identifying principles of good practice in undergraduate education. Among the principles identified are active learning, cooperation among students and frequent contact between faculty and students.[2]

3. Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. Review of Educational Research, 64(1), 1-35.

A powerful and persuasive conceptual piece which identifies "conditions under which small groups in classrooms can be productive." The author examines type of discourse between students in both routine learning and more conceptual learning and suggests how task instructions, student preparation and teacher role can be differentially effective in the two types of learning. The author also address status problems in group learning. Not an easy read for most, but well worth the effort.

4. Cuseo, J. (1992, Winter). Collaborative & cooperative learning in higher education: A proposed taxonomy. Cooperative Learning and College Teaching, 2, 2-5.

This excellent article attempts to identify the variety of cooperative and collaborative techniques used in higher education by developing a taxonomy based on the types of interaction: a) student-student, b) teacher-teacher, and c) student-teacher. Cuseo describes procedures which are often not clearly distinguished, including cooperative learning, collaborative learning, peer teaching and learning communities. He is a contributing editor to the Cooperative Learning and College Teaching newsletter and has written many articles dealing with empirical and theoretical issues relating to teaching and learning. Cooperative learning and its effects on student diversity, emotional development, critical thinking, and writing across the curriculum are among the topics he has addressed.

5. Davidson, N., & Worsham, T. (Eds.). (1992). Enhancing thinking through cooperative learning. NY: Teachers College Press.

A powerful book which addresses research, theory and practice concerning how cooperative learning can foster critical thinking. Among chapter authors are many leaders in cooperative learning as well as leaders in critical thinking, such as Robert Marzano, Arthur Costa and Toni Worsham. Most chapters deal with applications of small-group instruction to develop critical thinking, including a chapter dealing with science instruction and one dealing with math instruction. Highest recommendation.

6. Hertz-Lazarowitz, R., & Miller, N. (Eds.). (1992). Interaction in cooperative groups: The theoretical anatomy of group learning. Cambridge: Cambridge University Press.

This is an excellent sourcebook for those interested in academically rigorous discussions of empirical and theoretical issues in cooperative learning, focusing on K-12 populations. Difficult reading for most college faculty.

7. Johnson, D. W., & Johnson, R. T. (1989). Cooperation and competition: Theory and research. Edina, MA: Interaction Book.

A research summary which describes the impact of cooperative learning on a variety of outcome measures. Results are reported separately for students of varying ages/grades (grades 1 through college and adult). Over 600 studies are cited in this meta-analysis. Must reading for anyone interested in research on cooperative learning at any level.

8. Johnson, D. W., Maruyama, G., Johnson, R. T., Nelson, D., & Skon, L. (1981). Effect of cooperative, competitive and individualistic goal structures on achievement: A meta-analysis. Psychological Bulletin, 89, 47-62.

Influential meta-analysis of cooperative-learning research. A review of 122 studies (largely K-12) which compared the effect of cooperative, competitive and individualistic goal structures in promoting student achievement and productivity. Results of the meta-analysis indicate that cooperation was considerably more effective than competitive or individualistic goal structures. Potential mediating (explanatory) variables accounting for the results are described.[1]

9. Matthews, R. S., Cooper, J. L., Davidson, N., & Hawkes, P. (1995, July/August). Building bridges between cooperative and collaborative learning. Change, 2, 35-40.

An interesting description of the similarities and differences between cooperative and collaborative learning, co-written by authors identified with each of the two approaches. Includes a good annotated bibliography of resources in both fields.

10. Millis, B. J. (1991). Fulfilling the promise of the "seven principles" through cooperative learning: Action agenda for the university classroom. Journal on Excellence in College Teaching, 2, 139-144.

A good article which indicates how cooperative learning implements the Seven Principles of Good Practice in Undergraduate Education reported by Chickering and Gamson in The Wingspread Journal (AAHE). Highly recommended.[2]

11. O'Donnell, A. M., & Dansereau, D. F. (1992). Scripted cooperation in student dyads: A method for analyzing and enhancing academic learning and performance. In R. Hertz-Lazarowitz, & N. Miller (Eds.), Interaction in cooperative groups: The theoretical anatomy of group learning (pp. 120-141). Cambridge: Cambridge University Press.

A thought-provoking chapter by two leaders of cooperative-learning research in higher education. They detail their extensive research assessing the impact of various manipulations of cooperative-learning features on a number of outcome measures. Among the emerging findings they report: a) active engagement rather than passive involvement resulted in better performance on

a variety of outcome measures (many relating to scientific technical information), b) use of cooperative learning for one task resulted in successful transfer of skills to other individually-completed tasks, c) teacher-structured cooperative-learning activities rather than student-structured dyadic (paired) activities generally produced better cognitive and affective performance, and d) heterogeneous dyads performed better than homogeneous dyads (largely due to increased performance by the lower-achieving member of the dyad). Most of this chapter deals with a specific cooperative-learning technique using dyads, called Scripted Cooperation, used in short-term laboratory studies. However, this chapter is for serious students of cooperative learning in higher education. Dansereau and O'Donnell have conducted many studies of cooperative learning in higher education, most of which have been well-controlled, short-term studies using dyads.

12. Robinson, P., & Cooper, J. (1995). An annotated bibliography of cooperative learning in higher education: Part III--the 1990s. Stillwater, OK: New Forums Press.

The third in a series of annotated bibliographies completed by Cooper and his associates, all dealing with cooperative and collaborative learning in higher education (the others were published in 1989 and 1991). The 1995 bibliography contains 55 citations and is indexed by academic discipline (e.g., Physical Science, Engineering and Math, Biological and Health Sciences, Management and Business). There are separate sections for Research and Theory and for Applied work.

13. Sharan, S. (1990). Cooperative learning: Theory and research. New York: Praeger.

Although written with K-12 applications in mind, this book is must reading for anyone interested in research, theory and practice in cooperative learning. Twelve chapters written by various authors deal with such issues as causal mechanisms and cooperative learning, cooperative learning and achievement, and a perspective on research and practice in cooperative learning. Chapter authors include many of the influential thinkers in the cooperative-learning community, including Slavin and the Johnsons. Highly recommended.[2]

14. Totten, S., Sills, T., Digby, A., & Russ, P. (1991). Cooperative learning: A guide to research. New York: Garland.

A book of 390 pages in which the authors present annotated bibliographies of the research in cooperative learning. Separate chapters contain bibliographies for various types of cooperative learning (e.g., Jigsaw, Group Investigation), disciplinary areas, student outcomes affected by cooperative learning (e.g., mathematics, science, social skills) and other topics. The authors also present information on films, games, newsletters and organizations associated with cooperative learning. An excellent 18-page overview and introduction is also provided. The focus is largely on precollegiate work, reflecting the historical emphasis of cooperative-learning researchers. Must reading for anyone interested in research on cooperative learning (and interesting reading for practitioners wanting to find out more about applications of cooperative learning).[2]

Section 1.B. SMET-Related Cooperative-Learning Resources.

15. Basili, P. A., & Sanford, J. P. (1991). Conceptual change strategies and cooperative group work in chemistry. Journal of Research in Science Teaching, 28, 293-304.

An outstanding article comparing cooperative learning to a more traditional method of teaching introductory chemistry at a suburban community college. The researchers found that cooperatively-taught students had significantly lower misperceptions concerning chemistry concepts than traditionally-taught students and scored higher on an achievement test. The authors discuss four conditions for bringing about conceptual change in students first identified by Posner, et al. (1982): a) dissatisfaction with their present concepts, b) the correct concept must be intelligible, c) the correct concept must be plausible, and d) the correct concept must be useful. The authors present a fascinating discussion of how these conditions relate to conceptual change in chemistry using quantitative and qualitative data collection.

16. Bonsangue, M. (1994). An efficacy study of the calculus workshop model. CBMS Issues in Collegiate Mathematics Education, 4, 117-137.

An examination of an adaptation of Treisman's calculus workshop model for students at California State University, Pomona. Bonsangue found: a) no significant differences on a variety of pre-enrollment measures of achievement between minority students participating in the program and those not participating, b) minority students participating in the workshop had a .6 higher mean GPA in calculus than minority non-participants and a much higher completion rate for the calculus sequences and math-based majors, c) the effects on academic achievement and persistence were particularly powerful for women, d) black and Latino workshop participants achieved at or above the level of all other ethnic groups at CSU Pomona, as measured by GPA in calculus and number of attempts required to complete the calculus sequence.

17. Bonsangue, M. (1991, January). Achievement effects of collaborative learning in introductory statistics: A time series residual analysis. Paper presented at the Joint Annual Meeting of the Mathematical Association of America/The American Mathematical Society, San Francisco, CA.

A study showing the benefits of collaborative/cooperative learning in an introductory statistics class. Comparison of control and experimental groups showed no difference on the first examination but significant differences in favor of the experimental group at measurement points thereafter. The study found evidence to support collaborative/cooperative learning as a useful alternative teaching method in mathematics.[2]

18. Burron, B., James, M. L., & Ambrosio, A. L. (1993). The effects of cooperative learning in a physical science course for elementary/middle level preservice teachers. Journal of Research in Science Teaching, 30, 697-707.

A comparison of traditionally-versus cooperatively-structured laboratory sections of a physical science course for preservice teachers. Two sections of the lab were taught using the Johnson's Learning Together technique and two using a traditional format. No significant differences were found in student achievement between the two instructional formats. Classroom observations of the two groups revealed that the cooperatively-taught students demonstrated more gains in collaborative behavior than comparison students. A posttest of student satisfaction with the course given only to the cooperatively-taught students indicated high levels of satisfaction.

19. Chang, G., Cook, D., Maguire, T., Skakun, E., Yakimets, W. W., & Warnock, G. L. (1994). Problem-based learning: Its role in undergraduate surgical education. Canadian Journal of Surgery, 38(1), 13-21.

A report of the appropriate role of problem-based learning (PBL) in the undergraduate clinical surgery course. The authors report that meta-analyses of the effects of PBL in medical education indicate that it is equal to more traditional forms of instruction in fostering knowledge (rote) skills such as those tested in the National Board of Medical Examiners' tests. However, according to the authors, PBL produces more enthusiasm and more positive attitudes toward learning than more traditional methods.

20. Committee on the Mathematical Sciences in the Year 2000. (1991). Moving beyond myths: Revitalizing undergraduate mathematics. Washington, DC: National Academy Press.

A 65-page report of a committee of 20 academics, leaders of industry and public-policy makers, sponsored by the National Research Council. The report calls for: a) engaging college math faculty in issues of teaching and learning, b) elevating mathematics teaching to the same level as mathematics research, c) achieving parity for women and minorities in mathematics, and d) teaching in ways that engage students. The report decries overreliance on passive modes of instruction, including the lecture method, in favor of small-group instruction focusing on higher-order math skills.

21. Cooper, M. M. (1995). Cooperative chemistry laboratories. Journal of Chemical Education, 71, 307.

A description of cooperatively-taught chemistry labs at Clemson University which enroll as many as 2000 students per semester. Student teams work on three open-ended, multi-step projects per semester, rather than more traditional one-lab-period-closed exercises. TAs are trained to work with students as coaches and facilitators rather than teacher-experts. The author reports the results of a study in which half of the students in introductory chemistry received cooperatively-taught labs and the other half were taught using traditional procedures (all received the same lecture). She indicates that students in the cooperatively-taught labs reported more positive lab experiences and believed they learned more. Lecture-students' grades were 2-10% higher for women in cooperative labs than women in traditional labs. Course drop-out rate for women in the cooperatively-taught labs was 13%, compared with 21% for women in traditional labs. No achievement or drop-out rate differences were observed for men in the two lab formats.

22. Cooper, M. M. (1995). Cooperative learning: An approach for large-enrollment courses. Journal of Chemical Education, 72, 162-164.

The author describes the advantages and disadvantages of cooperative learning in general, and in large-lecture classes. She offers advice to instructors regarding preparation for cooperative-learning classes, with an emphasis on preparing for large classes. She reports on student attitudinal responses ("overwhelmingly positive") in a class of 190. Eight sample group-quiz problems that could be used in mid-lecture to stimulate discussion are also included. See Eric Mazur's article (#90) describing his work in physics for a similar lecture/quiz technique.

23. Courtney, D. P, Courtney, M., & Nicholson, D. (1992, November). The effect of cooperative learning as an instructional practice at the college level. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Knoxville, TN. (ERIC Document Reproduction Services No. ED 354 808)

A comparison of cooperative learning and a traditional lecture approach to the teaching of graduate-education statistics. The authors found no differences in achievement between the two sections on two multiple-choice achievement tests. They report highly favorable qualitative responses made by the cooperative learning students about self motivation, self efficacy, level of anxiety and social cohesiveness. This study has significant methodological flaws.[3]

24. Davis, R. B., Maher, C. A., & Noddings, N. (Eds.). (1990). Constructivist views on the teaching and learning of mathematics (Journal for Research in Mathematics Education Monograph No. 4). Reston, VA: National Council of Teachers of Mathematics.

A powerful exposition of the constructivist position as it relates to theory and practice in mathematics. A variety of authors in this theme issue of the journal describe the history and philosophy of constructivism and the implications of this position for learning and teacher training. Highly recommended.

25. DeClute, J., & Ladyshewsky, R. (1993). Enhancing clinical competence using a collaborative clinical education model. Physical Therapy, 73, 683-697.

A study which compared a 2:1 student to instructor ratio in the teaching of clinical skills in physical therapy with a more traditional 1:1 ratio. The authors found that the 2:1 ratio (which they characterized as a collaborative- or cooperative-learning model) produced higher performance on the clinical competence assessment form generated by the university. Three commentaries are appended to the article critiquing the collaborative model and the study itself. The authors' responses to the commentaries are also included.

26. Dees, R. L. (1991). The role of cooperative learning in increasing problem-solving ability in a college remedial course. Journal for Research in Mathematics Education, 22, 409-421.

A comparison of cooperatively- and traditionally-structured discussion sections of a remedial mathematics college course enrolling approximately 100 students per semester. The researcher found that cooperatively-taught students developed better higher-order math skills than the traditionally-taught students. The cooperatively-taught students had more skill in solving word problems in algebra and proof writing in geometry. The procedures used in the sections identified as using cooperative learning implemented somewhat informal small-group techniques, rather than formal cooperative-learning structures.

27. Duckwall, J. M., Arnold, L., Willoughby, T. L., Calkins, E. V., and Hamburger, S. C. (1990). An assessment of the student partnership program at the University of Missouri-Kansas City School of Medicine. Academic Medicine, 65, 697-701.

A report of a partnership program at the University of Missouri-Kansas City School of Medicine. The program combines a bachelor's degree with a medical degree in a six-year course of study. Third-year students are paired with fifth-year students in a two-month internal-medicine rotation required of all students during the last four years of the program. Teams of 12 students are supervised by medical faculty. Survey and interview results presented in this article report generally positive results of the student pairings. The authors recommend that those wishing to maximize success in similar programs should: a) have training sessions for students and teachers to

clarify expectations, teach interpersonal skills and engender commitment to the program, b) use teacher-directed assignment of pairs (rather than random assignment), and c) create an environment of cooperation rather than competition for grades.

28. Frierson, H. T. (1986). Two intervention methods: Effects on groups of predominantly black nursing students' board scores. Journal of Research and Development in Education, 19,(3) 18-23.

A study of 139 nursing students who attended a predominantly black state college. Students studying cooperatively for the state nursing board exam and who also received instruction in test-taking strategies received higher board exam scores than nursing students who received no intervention or who received just test-taking strategies instruction.[1]

29. Frierson, H. T., Jr. (1987, Spring). Academic performance in predominantly black nursing classes: Effects associated with intervention designed for standardized test preparation. Journal of Research and Development in Education, 20(3) 37-40.

An elaboration of the Frierson (1986) article (#28) dealing with the effects of cooperative learning on the performance of nursing students at a minority institution taking the state nursing certification exam. In the study described in this, and the 1986, article one group of students was exposed to a traditional-instruction method, another group received regular instruction plus eight hours of test-taking instruction. A third group of students received regular instruction plus twelve hours of instruction combining test-taking strategies with cooperative learning. Both experimental groups received higher GPAs than the traditionally-taught comparison group. However, the students receiving the cooperative-learning intervention had a substantially higher GPA than the students in the other two groups. In addition, the students in the cooperative-learning group increased their GPA from a Fall semester mean of 2.21 to a Spring semester mean of 3.09.

30. Garland, M. (1993). The mathematics workshop model: An interview with Uri Treisman. Journal of Developmental Education, 16, 14-16, 18, 20, 22.

An interview with Uri Treisman whose work with minority students in calculus brought national attention to small-group instruction in the 1980s. Treisman indicates that to increase the academic performance of at-risk students a fundamental re-examination of the curriculum and related services must be instituted (including but not limited to cooperative learning). An interesting insight into the mind of a successful educational change agent examining twenty years of tilting at the status quo.

31. Heller, P., Keith, R., & Anderson, S. (1992). Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving. American Journal of Physics Teachers, 60, 627-636.

32. Heller, P., & Hollabaugh, M. (1992). Teaching problem solving through cooperative grouping. Part 2: Designing problems and structuring groups. American Journal of Physics Teachers, 60, 637-644.

A fascinating description of how cooperative learning can be combined with explicit ("expert") problem-solving strategies to foster improved problem solving in college physics classes (although this article would be of interest to those in math, engineering and a variety of other science-related fields as well). Part 1 details how the authors taught a five-step problem-solving strategy to their students and combined the techniques with the use of context-rich, real-world problem sets (as opposed to rote, textbook problems). The problem sets were solved in cooperative-learning groups. The authors found that such a curricular and instructional approach had a significant impact on conceptual understanding, usefulness of the physics description and the matching of the description with the mathematics needed to solve the problems. They also found that the positive effect of the intervention was significant for students at all ability levels (including the best students). When students in the classes described above were compared with students taught with more traditional instruction on two exercise problems, the cooperative learning students performed at a much higher level. Part 2 describes practical advice for implementing the techniques described in Part 1. The authors offer their advice on such issues as optimal group size (three or four on a team is better than two, and teams of three are the best) and gender composition of the three-person teams favored by the authors (same sex teams, and teams with two females and one male are better than teams with two males and one female). The authors favor heterogeneously-formed teams based on achievement. They also give advice on forming and testing "context-rich" problems. Highest recommendation for college teachers in all disciplines.[3]

33. Hooper, S., Sales, G., & Rysavy, S. D. M. (1994). Generating summaries and analogies alone and in pairs. Contemporary Educational Psychology, 19, 53-62.

A short-term study in which students worked alone or in pairs to master a 6200-word text passage dealing with marine life. Some students were given instructions to use analogies in learning the content of the passages, others were given instructions to generate summaries of paragraphs within the passages and others were given neither analogy nor summarizing (cognitive elaboration) strategies. Students working alone scored higher than students working in pairs on a test of rote knowledge of the passage content. Students using cognitive-elaboration strategies scored higher than those using analogies. Learning rates or efficiency was higher for students working alone. The authors hypothesize that the relatively poor performance for pairs may be that the dyads did not perceive positive interdependence between each other and did not participate in self evaluation, factors considered essential in small-group learning, according to Johnson, Johnson, and Smith (1991) and other cooperative-learning theorists.[2]

34. Jones, J. D., & Brickner, D. (1996, June). Implementation of cooperative learning in a large-enrollment basic-mechanics course. Paper presented at the American Society for Engineering Education Annual Conference, Washington DC.

A well-designed comparison of two sophomore-level basic-mechanics classes lasting one year and having enrollments of around 100. The cooperatively-taught class used a highly-structured procedure consisting of mini-lecture, sample problem analysis and collaborative problem sets which were completed during each class meeting. The traditionally-taught class used a lecture method of instruction. The cooperatively-taught classes generally achieved at a higher level on in-class exams, course grade and reported more positive attitudes on a survey of work habits and attitudes, particularly attitudes toward the teacher. There were positive anecdotal responses concerning the course from 90-95% of the students in the cooperatively-taught section. The authors suggest that random formation of groups is as effective as teacher formation of heterogeneous groups. They base their perceptions about group formation on their in-class experiences rather than more formal research procedures.

35. Kacer, R., Rocklin, T., & Weinholtz, D. (1992). Individual versus small group instruction of computer applications: A quantitative and qualitative comparison. Journal of Computing in Teacher Education, 9(1), 6-12.

A study in which groups of students in a computer-applications class were randomly assigned to work either alone or in cooperative-learning groups. Quantitative measures revealed no difference between the groups on achievement or attitude. Qualitative measures suggested that the cooperative-learning students engaged in more planning activities and had better conceptual understanding of the content.

36. Lawrenz, F., & Munch, T. W. (1984). The effect of grouping of laboratory students on selected educational outcomes. Journal of Research in Science Teaching, 21, 699-708.

A study comparing three ways of forming teams in a laboratory science class taught to undergraduate education students. Students in groups formed heterogeneously and homogeneously (based on reasoning ability) received higher scores on a posttest of science knowledge relative to students in self-selected teams. Students in classes using heterogeneously-formed teams did not differ in achievement from students in classes using homogeneous grouping. No differences between the three grouping conditions were observed in measures of students' perceptions of classroom environment.

37. Lord, T. R. (1994). Using constructivism to enhance student learning in college biology. Journal of College Science Teaching, 23, 346-348.

A short article in which the author presents a detailed description of a cell-division lesson in a biology class for non-majors. The author uses as his constructivist conceptual base a 5E model attributed to Rodger Bybee. The five elements of the teaching model are Engage, Explore, Explain, Elaborate and Evaluate. Must reading for biology teachers and others interested in keeping students actively involved in science classes.

38. Lundeberg, M. A., & Moch, S. D. (1995). Influence of social interaction on cognition: Connected learning in science. Journal of Higher Education, 66, 312-335.

A qualitative study that uses Supplemental Instruction in health-science classes taken by female nursing students. Based on a variety of data-collection procedures, the authors suggest that female students in science classes may learn best when: a) a sense of cooperation and community is fostered in the classroom, b) risk taking is encouraged, c) power is shifted from the instructor to the students, d) students assess their own and their colleagues' knowledge in an ongoing fashion, and e) abstract concepts are related to the students' lives.

39. Marks, M. (1991). Cooperative learning in chemistry. College Park, MD: Center for Teaching Excellence.

Marks describes the process of designing and implementing cooperative learning in an honors chemistry class at a university. He reports favorable results from questionnaires administered to the students regarding attitudes about cooperative learning, and includes some of the dialogue from student interviews about the cooperative-learning techniques used in the class. This honors chemistry class had a higher average score on a final exam that was also administered to a regular section of chemistry and another honors section not using cooperative-learning techniques. The instructors were also interviewed and said that cooperative learning "keeps the students involved," and that they do not teach but "provide a way for students to learn."[2]

40. Martin, G. D. (1995). Cooperative learning in chemistry tutorials: Assessing the effectiveness of group learning strategies. Journal of College Science Teaching, 25, 20-23.

In interesting action-research study of an introductory chemistry course for non-majors. Students in tutorial classes of 56 students were exposed to three versions of Jigsaw, a cooperative-learning structure in which students work in expert groups to learn specific content, then teach that content to others in their four-person base groups. In Method One, each of the base group members were given specific questions to answer in their expert groups and then shared those answers with their base groups. In Method Two, team members were given general areas of content to study in expert groups, then went back to their base groups, where they were given

specific questions to answer (and, it was hoped, to teach to the other members of their base groups). In Method Three, members were given general areas to study in expert groups, then they were given specific questions to answer in their base groups, just as in Method Two. In Methods One and Two, base teams submitted one answer sheet for the entire team. The same group grade was assigned for all members of a given base team. Method Three differed from Methods One and Two in that each base group member submitted individual worksheets and received individual grades. The author reports that students overwhelmingly preferred Method Three. He also reports that students in Methods One and Two appeared to be inclined to simply staple their individual work together and not discuss the sub-components of the entire task. The finding that group work and group grading is less effective than group work combined with individual accountability for individual achievement is consistent with good cooperative-learning practice as noted by scholars such as Robert Slavin and Spencer Kagan. Collaborative-learning practitioners and theorists often endorse group grading.

41. Mohr, P. H. (1995). Cognitive development in college men and women as measured on the Perry scheme when learning and teaching styles are addressed in a chemical engineering curriculum. (Doctoral dissertation, North Carolina State University, 1995). Dissertation Abstracts International, 56(08), 3020A.

A study comparing differences in Perry's cognitive-development positions for undergraduate chemical-engineering students exposed to cooperatively-taught classes versus those exposed to more traditional forms of instruction. Students (both male and female) exposed to the cooperatively-taught classes demonstrated greater gains in Perry positions than students exposed to traditional-instructional formats.

42. Norwood, K. S. (1995). The effects of the use of problem solving and cooperative learning on the mathematics achievement of underprepared college freshmen. Primus, 5, 229- 252.

A study of a relatively large section of a remedial (non-credit) math class taught using cooperative learning versus a class taught using a lecture format at North Carolina State University. Students in the cooperatively-taught section did substantially better in the next (for credit)

precalculus math class: a) 70% of the experimental-group students passed the precalculus class (versus 46% of the comparison-group students), and b) 55% of the experimental-group students equaled or exceeded the prerequisite class grades for the precalculus course (versus 10% among the comparison-group students).

43. Posner, H. B., & Markstein, J. A. (1994). Cooperative learning in introductory cell and molecular biology. Journal of College Science Teaching, 23, 231-233.

A study comparing the use of cooperative learning to more traditional methods of teaching discussion sections of large enrollment introductory cell and molecular biology courses. The researchers found that: a) retention rates for minority students in cooperatively-taught sections substantially exceeded rates for similar students in traditional sections, b) grades for regularly-admitted minority students were higher in the cooperatively-taught sections relative to regularly-admitted minority students in traditionally-taught sections, c) student attitudes in cooperatively-taught sections were generally positive, and d) minority-student enrollment in advanced biology courses increased after implementation of cooperative learning in the introductory course. However, cooperatively-taught sections did not produce significantly different effects on minority-students' grades among special-admissions students relative to comparable students in traditionally-taught classes. Also, the study was confounded in that cooperatively-taught sections had more than one discussion leader per section.

44. Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66, 211-227.

A fascinating article that argues that for conceptual change (accommodation) to occur in students four conditions must be present. First, there must be dissatisfaction with existing conceptions. Second, the new conception must be intelligible to the learner. This intelligibility is often fostered by the use of analogies and metaphors. Third, the new conception must appear initially plausible. Often this involves consistency of the new concept with existing knowledge. Fourth, the new concept should suggest the possibility of a fruitful extension to new areas of inquiry. The authors discuss the implications of their formulation for curriculum and teaching.

Although the authors do not specifically discuss cooperative learning, their recommendations for teaching are consistent with cooperative-learning techniques (e.g., creating cognitive conflict, organizing instruction so the teacher is a facilitator not a lecturer, using multiple presentation modes and multiple modes of assessment for student errors in thinking). Highest recommendation.

45. Roth, W., & Roychoudhury, A. (1993). Using Vee and concept maps in collaborative settings: Elementary education majors construct meaning in physical science courses. School Science and Mathematics, 93, 237-244.

A qualitative study of the impact of using collaborative learning, concept maps and Vee mapping in a course in physics methods for elementary education (n=27). Authors report that over the term the use of collaborative learning and mapping caused students to produce maps containing larger numbers of meaningful, relevant concepts and increased positive affect (attitude) of students toward the pedagogy.[2]

46. Ryan, M. A., Robinson, D., & Carmichael, J. W., Jr. (1980). A Piagetian-based general chemistry laboratory program for science majors. Journal of Chemical Education, 57, 642-645.

Describes a chemistry program at a historically-black college based on the principles of collaborative learning and Piaget. Data-analysis focus is on a chemistry lab taught using a Piagetian/collaborative approach versus a more traditional approach. Authors conclude that students performed equally well on a "skills-based" final exam but that experimental-group students performed better on a Piagetian-like test, rated the course higher on a post-course evaluation and had better attendance.[2]

47. Shaw, M. E., Ackerman, B., McCown, N. E., Worsham, A. P., Haugh, L. D., Gebhardt, B. M., & Small, P. A., Jr. (1979). Interaction patterns and facilitation of peer learning. Small Group Behavior, 10, 214-223.

A study conducted on first-year medical and dental students enrolled in an immunology course. The authors found that group members who gave information to peers in their small groups were perceived as facilitating group performances. However, group members asking for information were more important in actual facilitation of group learning.

48. Shearn, E., & Davidson, N. (1989, March). Use of small-group teaching and cognitive developmental instruction in a mathematical course for prospective elementary school teachers. Paper presented at the Meeting of the American Education Research Association, San Francisco.

Two groups of teacher trainees taking an introductory math course were exposed to cooperative learning. Cognitive development (based on Perry's model) and students' self concept increased from pretest to posttest.[2]

49. Springer, L., Stanne, M. E., & Donovan, S. (1997, April). Effects of cooperative learning on academic achievement among undergraduates in science, mathematics, engineering, and technology: A meta-analysis (Unpublished Report). Madison, WI: University of Wisconsin-Madison and National Center for Improving Science Education, The National Institute for Science Education.

A significant addition to the literature on cooperative learning in SMET disciplines in higher education. The authors provide a brief introduction to cooperative-learning research and theory, then detail their meta-analysis methodology, results and conclusions. They focused on classroom-based research and concluded that "cooperative learning is more effective than traditional forms of instruction" in science and mathematics courses for three primary outcomes: achievement, attrition and attitude toward the discipline. This study is the best evidence documenting the power of small-group instruction in SMET disciplines since it summarizes the work described in 86 publications and incorporates the findings of 39 research studies that used well-controlled methodologies with college and adult populations.

50. Steen, L. A. (1992). 20 questions that deans should ask their mathematics department (Or, that a sharp department will ask itself.). AAHE Bulletin, 44,(9), 3-6.

A highly readable brief article that calls for a re-examination of the ways in which mathematics is taught at the college level. The author, a contributor to the National Research Council publication Moving Beyond Myths: Revitalizing Undergraduate Mathematics, summarizes the findings of that 1991 report. He also describes the 1989 report of the National Council of Teachers of Mathematics. Both publications call for more active learning/teaching and a greater

emphasis on higher-order thinking in the math classroom. The central role of mathematics in influencing attrition rates, particularly for women and minorities, is also addressed. The author calls for greater attention to professional development for college mathematics teachers dealing with such topics as effective teaching and assessment.

51. Terwilliger, C. D., & Groccia, J. E. (In press). A comparative assessment of students' experiences in two instructional formats of an introductory materials science course. Journal of Engineering Education, 86.

A comparison of two ways of teaching a materials science (engineering) course for classes of 62-116 students at WPI (formerly Worcester Polytechnic Institute). A traditional-lecture approach was compared with an active-learning procedure which included: a) active lectures, b) group assignments, and c) use of cooperative learning. The active-learning approach used undergraduate Peer Learning Assistants and graduate Teaching Assistants to manage the learning teams. The active-learning approach was equal to or superior to the traditional approach in many outcome measures including: a) rote and higher-order knowledge of course content, b) interpersonal skills, and c) course satisfaction.

52. Tobias, S. (1990). They're not dumb. They're different. A new "tier of talent" for science. Change, 22, 110-30.

An excerpt from Tobias' well-known book They're Not Dumb. They're Different. Tobias conducted a qualitative study in which seven auditors attended physics and chemistry classes as if they were students and kept logs of their responses to the classes. Tobias found that women perceive science classes as unfriendly and are "uncomfortable" working in the intensely competitive environment of many introductory science classes. Tobias' findings coincide with a University of Michigan study that found that women (and other students who were academically qualified to major in science but chose not to) would perform better in "cooperative and interactive modes of learning" and "if scientific knowledge were more closely linked to important societal issues."

53. Treisman, U. (1985). A study of the mathematics performance of black students at the University of California, Berkeley (Doctoral dissertation, University of California, Berkeley, 1986). Dissertation Abstracts International, 47, 1641-A.

A description of Treisman's important research concerning collaborative learning with minority math students at Berkeley. Black students enrolled in this enrichment program received significantly higher grade-point averages in freshman calculus, graduated in math-based majors four times more often and had significantly lower attrition rates than comparable black students not enrolled in the program. Treisman's model is now used at a number of colleges in math, science and engineering programs, with minority and other students.[1]

54. Valentino, V. R. (1988). A study of achievement, anxiety, and attitude toward mathematics in college algebra students using small group interaction methods. (Doctoral dissertation, West Virginia University, 1988). Dissertation Abstracts International, 50(02), 379A.

A comparison of a highly-structured form of cooperative learning known as STAD (Slavin, 1995) with a lecture method of teaching college algebra. Students in the cooperatively-taught section had higher course-completion rates, lowered math anxiety and more positive attitudes toward mathematics. Math achievement scores were generally higher in the cooperatively-taught class (though not statistically significant).

55. Watson, B. B., & Marshall, J. E. (1995). Effects of cooperative incentives and heterogeneous arrangement on achievement and interaction of cooperative-learning groups in a college life science course. Journal of Research in Science Teaching, 32, 291-299.

A relatively well-controlled study of cooperative incentives and heterogeneous grouping in a college life-science course for education majors. The treatment lasted four weeks and involved using a Jigsaw instructional technique with a multiple-choice science-achievement test used as the dependent measure. Jigsaw is a technique in which each team member is responsible for learning different elements of an assignment, then teaching that element to teammates. The researchers reported no achievement differences for students put in 3-4 person cooperative teams formed heterogeneously versus homogeneously (based on science achievement pretest scores). No achievement differences were found for students given grade incentives for group performance relative to students given individual performance grades. The authors report that these findings are inconsistent with research and practice reported at the precollegiate level (although they report that the research on homogeneous versus heterogeneous team formation at precollegiate levels is inconsistent).

56. Weissglass, J. (1993). Small-group learning. The American Mathematical Monthly, 100, 662-668.

A personal account of how one mathematics professor came to use small-group learning in his college classes. The author offers advice on a number of issues relating to small-group instruction, including how to get started, how to address student needs and concerns and how to develop institutional support. Weissglass has been at the forefront of reform in mathematics education for many years.

57. Yager, R. E., & Huang, D. (1994). An alternative approach to college science education for nonscience majors. Journal of College Science Teaching, 24, 98-100.

A short article dealing with small-group instruction using a problem-based approach in a human biology course for education majors in Taiwan. Students exposed to the collaborative, problem-based approach performed at a higher level than students exposed to a lecture method on posttest measures of: a) mastery of biology knowledge, b) understanding of scientific processes and application, c) attitudes toward science, and d) creativity.

Section 2. APPLICATIONS

Section 2.A. General Cooperative-Learning Resources.

58. Abrami, P. C., Chambers, B., Poulsen, C., De Simone, C., d'Apollonia, S., Howden, J. (1995). Classroom connections: Understanding and using cooperative learning. Toronto, Ontario, Canada: Harcourt Brace.

A very good handbook that covers empirical, theoretical and practical issues regarding cooperative learning. The authors treat such topics as theoretical explanations for the efficacy of cooperative learning (e.g., cognitive, behavioral, humanistic) and the research base for its effectiveness. They also treat a variety of specific approaches to cooperative learning (e.g., STAD, Jigsaw, Group Investigation). A good contribution to the field. Written for both precollegiate and college teachers.

59. Abercrombie, M. L. J. (1974). Aims and techniques of group teaching. London: Society for Research into Higher Education, Ltd.

A short book describing a variety of small-group techniques, including syndicate learning, peer tutoring and associative group discussion. Emphasis is on work conducted in Britain. Abercrombie's work on collaborative learning with medical students at the University of London is considered by Kenneth Bruffee and others as seminal.[1]

60. Cooper, J. L., Prescott, S., Cook, L., Smith, L., Mueck, R., & Cuseo, J. (1990). Cooperative learning and college instruction: Effective use of student learning teams. Long Beach, CA: The California State University Foundation on behalf of California State University Institute for Teaching and Learning.

A 50-page workbook designed for college instructors interested in incorporating cooperative learning into their courses with minimal disruption to existing teaching formats such as lecture and lecture-discussion. Among the topics treated are the benefits of using cooperative learning, critical features, organizing the classroom, trouble-shooting problems in implementation, and tips on getting started. Very practical.[2]

61. Cottell, P. G., Jr., & Millis, B. J. (1994). Complex cooperative learning structures for college and university courses. To Improve the Academy: Resources for Faculty, Instructional, and Organizational Development, 13, 285-307.

An outstanding complimentary chapter to the Millis (1995) chapter (citation 71 of this bibliography). Cottell and Millis elaborate on some of the structures presented in the Millis chapter and also present information on team roles and structures designed to foster higher-order skills, information not covered in detail in the 1995 Millis chapter. Highest recommendation for clear, interesting presentation of powerful teaching ideas.

62. Feichtner, S. B., & Davis, E. A. (1984-1985). Why some groups fail: A survey of students' experiences with learning groups. The Organizational Behavior Teaching Review, 9(4), 58-71.

A description of good and bad collaborative-learning procedures in college settings. Very practical.[1]

63. Forest, L. (Ed.). Cooperative Learning.

Special-theme issues of the magazine have dealt with the teaching of math and science. In 1993 they published a theme issue dealing with higher education, though most issues of the magazine tend to focus on precollegiate applications. A good blend of applied research, theory and practice, with a decided emphasis on practice. Persons interested in subscribing may contact the magazine at (514) 848-2020.

64. Gabelnick, F., MacGregor, J., Matthews, R. S., & Smith, B. L. (Vol. Eds.) & R. E. Young (Series Ed.). (1990). Learning communities: Creating connections among students, faculty, and disciplines. New directions for teaching and learning, 41. San Francisco: Jossey-Bass.[2]

An excellent source which describes a number of learning communities. Among the issues treated are the history of learning communities, faculty and student perspectives, and curriculum issues relating to the subject. The last chapter describes a variety of resources for those wishing to find out more about learning communities. Recommended.

65. Goodsell, A., Maher, M., & Tinto, V. (1992). Collaborative learning: A sourcebook for higher education. University Park, PA: National Center on Postsecondary Teaching, Learning, & Assessment.

A good sourcebook which contains a number of reprints and original articles by leaders in the cooperative- and collaborative-learning movement, including Kenneth Bruffee, Barbara Leigh Smith, Jean MacGregor, Karl Smith and Roger and David Johnson. Leigh Smith and MacGregor contributed an excellent article which identifies a variety of collaborative techniques, including discussions of problem-based learning, guided design, cooperative learning, writing groups and learning communities. The sourcebook includes an annotated bibliography and a listing of sites and networks where collaborative learning is used. National Resource Center materials can be ordered by calling (814) 865-5917.[2]

66. Johnson, D. W., Johnson, R. T., & Smith, K. A. (1986). Academic conflict among students: Controversy and learning. In R. S. Feldman (Ed.), The social psychology of education: Current research and theory (pp. 199-231). Cambridge: Cambridge University Press.

A textbook chapter which describes a specific form of cooperative learning known as structured controversy. In structured controversy, members of the same learning team assume different positions concerning an issue in an attempt to ultimately maximize learning for all team members through discussion and research relating to the positions. Authors conclude that this technique sparks conceptual conflict within students, creates epistemological curiosity and promotes higher-level thinking skills.[1]

67. Johnson, D. W., Johnson, R. T., & Smith, K. A. (1991). Active learning: Cooperation in the college classroom. Edina, MN: Interaction Book.

An excellent workbook which provides a wealth of practical information concerning cooperative learning and college teaching. This is the book to buy if you only purchase one general source of information on the subject. Highest recommendation. To purchase this book and other materials call (612) 831-9500.[2]

68. Kadel, S., & Keehner, J. A. (1994). Collaborative learning: A sourcebook for higher education, vol. II. (K. Parsley, Ed.). University Park, PA: National Center on Postsecondary Teaching, Learning, & Assessment.

The second sourcebook published by the National Center (which was funded by the U.S. Department of Education's Office of Educational Research and Improvement). The book begins with the text of a keynote presented by Zelda Gamson, which presents her view of collaborative learning from both a historical and a contemporary perspective. This is followed by a series of short articles by a number of figures in cooperative and collaborative learning. There is also a series of somewhat sketchy one- and two-page descriptions of both generic applications of collaborative learning and applications in specific disciplines, including a few in SMET.

69. Kagan, S. (1994). Cooperative learning. San Juan Capistrano, CA: Resources for Teachers.

Kagan's workbook is a rich source of ideas concerning applications of cooperative learning to a host of outcomes and issues. Over 100 activities or cooperative-learning structures are reported in the index, most of which appear to be field-tested. An invaluable source of ideas, checklists, lesson plans and materials are provided. The workbook is clearly intended for elementary teachers but the structures described can easily be adapted to the college classroom. To purchase this text and additional cooperative-learning materials call 1-800-933-2667.

70. Michaelsen, L., Watson, W. E., & Sharder, C. B. (1984-1985). Informative testing--a practical approach for tutoring with groups. The Organizational Behavior Teaching Review, 9 (4), 18-33.

A description of a collegiate collaborative-learning technique using organizational behavior as a framework. Focus is on the use of highly-structured criterion-referenced testing combined with highly-structured group activities designed to diagnosis and remediate students' learning.[1]

71. Millis, B. J. (1995). Introducing faculty to cooperative learning. In W. A. Wright (Ed.), Teaching improvement practices: Successful strategies for higher education (pp. 127-154). Bolton, MA: Anker.

A great introduction to cooperative learning for the novice, as well as a step-by-step guide to the faculty developer interested in introducing active learning to his/her campus. Millis presents: a) the rationale for, and research base of, cooperative learning; b) descriptions of selected cooperative-learning techniques; c) procedures for getting started in cooperative learning; and d) resources available for both novice and intermediate practitioners. An excellent resource which provides busy faculty with an overview of cooperative learning in higher education. Highest recommendation.

72. O'Donnell, A., & Adenwalla, D. (1989, July). Scripted cooperation and knowledge maps: Information processing tools applied to deaf education. In D. Martin (Ed.), International

symposium on cognition, education, and deafness, 2 (pp. 836-854). Washington, DC. (ERIC Document Reproduction Service No. ED 313 849)

O'Donnell and Adenwalla describe the uses of scripted cooperative learning and the use of knowledge mapping. Scripted cooperation is a method for structuring cooperative learning which uses student pairs. Students alternate roles as recaller of information and checker of the correctness of the recall. Both members of the dyad attempt to elaborate and use other metacognitive strategies to assist retention. In knowledge mapping, information is presented in two-dimensional representations. Idea units are connected to other ideas using a series of links in order to render relationships more explicit to the teacher and students. Both scripted cooperation and knowledge mapping are potentially powerful metacognitive additions to cooperation which should be considered by cooperative-learning practitioners interested in enhancing long-term retention and critical thinking. Highly recommended.[2]

73. Prescott, S. (1996, Fall).Trouble-shooting. Cooperative Learning and College Teaching, 7, 5-6.

This article is one in a series of very helpful articles written by the author for the Cooperative Learning and College Teaching newsletter. In this article she focuses on the importance of clarity of content in designing cooperative-learning tasks. She notes that many instructors are much too global in their thinking about course content and what knowledge students should be able to demonstrate regarding that content. She also indicates that many instructors are unclear when telling cooperative groups how to complete exercises. Prescott writes a column for the newsletter which addresses implementation issues in cooperative learning. She has addressed such topics as cooperative learning and: a) students' reflective thinking, b) teacher planning, c) when to use small-group work, d) graphic organizers, and e) student empowerment.

74. Sharan, Y., & Sharan, S. (1992). Expanding cooperative learning through group investigation. NY: Teachers College Press.

A well-written text describing Group Investigation, one of the most powerful cooperative learning procedures for fostering higher-order thinking. Group Investigation is a complex cooperative procedure in which students take responsibility for planning, carrying out and reporting on research projects which can last many weeks. Sharan and Sharan, who popularized the technique, describe the approach and offer example of Group Investigation within several disciplines. They also discuss the history of the approach and its effects on students. The examples use K-12 populations but the book is of value to all disciplines.

75. Smith, K. A. (1996). Cooperative learning: Making "groupwork" work. In R. J. Menges (Series Ed.) & C. C. Bonwell, & T. E. Sutherlund (Vol. Eds.), Using active learning in college classes. New directions for teaching and learning 67, (pp.71-84). San Francisco: Jossey-Bass.

A good general introduction by a leader in applications of cooperative learning to higher education. This short chapter introduces essential elements of cooperative learning and describes issues and problems that newcomers need to consider in implementation. A jigsaw technique is described, identifying the steps to be followed by the instructor, and a sample information sheet for students is included.

76. Whitman, N. A. (1988). Peer teaching: To teach is to learn twice (ASHE-ERIC Higher Education Report No. 4) Washington, DC: Association for the Study of Higher Education.

An excellent short book which describes five major approaches to peer teaching and summarizes the empirical support for each. The techniques described include the use of teaching assistants, tutors, and counselors within and outside of the classroom. Student partnerships and student work groups which closely approximate the critical features of cooperative learning are described. Text includes a good reference section.[2]

Section 2.B. SMET-Related Cooperative-Learning Resources.

77. Davidson, N. (Ed.). (1990). Cooperative learning in mathematics. Menlo Park, CA: Addison-Wesley.

A handbook focusing largely on cooperative learning at the K-12 level. However, many of the exercises and descriptions can be adapted for use in college-level mathematics. Chapter authors include many of the leaders in application of cooperative learning to mathematics, including

Elizabeth Cohen, Julian Weissglass, Marilyn Burns and Neil Davidson. Davidson's introduction and review chapter are especially good.

78. Dedic, H., Rosenfield, S., d'Apollonia, S., & De Simone, C. (1994, Spring). Using cooperative concept mapping in college science classes. Cooperative Learning and College Teaching, 4, 12-15.

The authors describe a combination of cooperative learning and concept mapping in college science courses. They indicate that Cooperative Concept Mapping enhances students' knowledge acquisition, organization and metacognition. The authors offer advice to teachers interested in introducing this strategy. They provide an example of how a team of students interact using Cooperative Concept Mapping in solving a physics problem. The authors report success in implementing the procedures in college physics, biology, statistics and astronomy classes.

79. Della-Piana, C. K., Villa, E. Q., & Pinon, S. D. (1996, June). Using cooperative learning in a freshman summer engineering orientation program. Paper presented at the American Society for Engineering Education Annual Conference, Washington, DC.

Describes a required summer bridge program for 200-300 computer science and engineering students at the University of Texas at El Paso, the largest university in the U.S. with a majority Hispanic student population. The program lasts for one week and is based on cooperative-learning principles. Program-evaluation information indicated that the program was rated successful on several criteria. Ratings information was obtained by a questionnaire regarding the quality of the math workshops, group projects and work related to academic success. Ninety-seven percent of respondents reported that they would recommend the summer session to friends.

80. Felder, R. M., & Brent, R. (1994). Cooperative learning in technical courses: Procedures, pitfalls, and payoffs. Raleigh: North Carolina State University. (ERIC Document Reproduction Service No. ED 377 038)

A very practical discussion of how Felder implements cooperative learning in his five-course chemical-engineering sequence. The authors introduce the features of cooperative learning and describe a number of cooperative exercises that have worked well in Felder's courses (both in-

class and out-of-class). They also present a brief case study of the five-semester sequence. Finally, the authors address common concerns expressed by faculty members considering adoption of cooperative learning and the authors' responses to these concerns. Highest recommendation.

81. Felder, R. M. (1991). It goes without saying. Chemical Engineering Education, 25, 132-133.

This interesting short article takes the reader step-by-step through a one-hour small-group problem-solving exercise for a sophomore course in chemical engineering. Felder set up a problem for his students and then guided them through a series of interim solutions which ultimately led to the final resolution of the problem. In his article, Felder points out how the exercise required his students to use information related to a number of important concepts within the course and related courses, yielding a level of understanding much more profound than that achieved with his former teaching style, the lecture. Although the lesson dealt with a very technical area of engineering, the step-by-step Guided Design approach taken can be used in a variety of courses.[3]

82. Hagelgans, N. L., Reynolds, B. E., Schwingendorf, K., Vidakovic, D., Dubinsky, E., Shahin, M., & Wimbish, J. G., Jr. (Eds.) (1995). A practical guide to cooperative learning in collegiate mathematics (MAA Notes No. 37). Washington, DC: Mathematical Association of America.

A relatively short book designed to introduce the college math instructor to cooperative-learning research, theory and practice. A number of sample activities are described from several math courses. The authors also describe the results of a survey returned by 42 college math teachers who use cooperative procedures. Very applied and easy to read.

83. Hart, F. L., & Groccia, J. E. (1994, February). An integrated, cooperative learning oriented freshman civil engineering course: Computer analysis in civil engineering. Paper presented at the Freshman Year Experience Conference, Columbia, SC.

Summary of a presentation which describes innovative approaches being used at Worcester Polytechnic Institute (WPI) in the undergraduate curriculum. This description focuses on the use of formal- and informal-learning teams and computers in the teaching of a civil-engineering class.

Both graduate and undergraduate aides are used to facilitate group functioning. At Worcester a premium is put on oral presentation of laboratory findings and integration of knowledge. Worcester has taken a leadership role in institutionalizing cooperative learning across many SMET disciplines.

84. Hassard, J. (1990). Science experiences: Cooperative learning and the teaching of science. Menlo Park, CA: Addison-Wesley.

A useful workbook of science activities describing a number of cooperative-learning structures. Although designed for elementary classrooms, the ideas presented may be of value to science teachers at all levels. The first three chapters include introductory material related to experiential learning, brain research, holistic instruction and shifts in instructional paradigms from product/outcome orientations to process/student-oriented approaches.

85. Johnson, D. W., & Johnson, R. T. (Eds.). (1991). Learning mathematics and cooperative learning: Lesson plans for teachers. Edina, MN: Interaction Books.

A set of lesson plans using cooperative learning developed by teachers, administrators, adult educators and college professors. The focus is on K-12 math instruction but the procedures can easily be adapted for collegiate applications.

86. Klemm, W. R. (1995, Spring). Computer conferencing as a cooperative learning environment. Cooperative Learning and College Teaching, 5, 11-13.

A description of the use of cooperative computer conferencing in a neuroanatomy class. The author criticizes the use of E-mail and listservs in college courses and argues for his method of conferencing using hypermedia links to address weekly issues relating to brain organization and functioning. The weekly computer-based activities include student ratings of one another's performance and required "insights" relating to lecture content. A very elaborate organizational plan for combining cooperative learning and technology in the classroom.

87. Laws, P. W., Rosborough, P. J., & Poodry, F. J. (1995). Women's responses to an activity-based introductory physics program. In R. J. Menges (Series Ed.) & J. Gainen, & F. W.

Willemsen (Vol. Eds.), Fostering student success in quantitative gateway courses. New directions for teaching and learning 61, (pp.77-87). San Francisco: Jossey-Bass.

An interesting short chapter that describes the physics workshop curriculum at Dickinson College. The authors use a variety of collaborative-learning procedures and often use a four-part learning technique based on the work of cognitive psychologist David Kolb. The authors report that students taught using their small-group procedure mastered higher-order physics concepts in much larger numbers than students taught more traditionally, and generally have more positive attitudes toward a variety of learning experiences. Women students at Dickinson were as likely to major in physics as their male colleagues. The authors also note that a number of students, including about 20% of the female students, did not express positive attitudes about the small-group workshop approach. The authors attribute much of this to prior negative experiences working in small groups and to feelings that the instructors should present the information in a clear and straight-forward lecture format.

88. Leron, U., & Dubinsky, E. (1995). An abstract algebra story. American Mathematical Monthly, 102, 227-242.

An outstanding article in which the authors describe teaching three concepts in algebra using small-group instruction with computers. The authors include typical student discussions that take place as they work collaboratively on the problems. This is a very detailed discussion with step-by-step explications of how students construct meaning using small-group procedures. The authors also present and respond to objections to their procedures. Highly recommended.

89. Long, G. A. (1989). Cooperative learning: A new approach. Journal of Agricultural Education, 30(2), 2-9.

An article which describes a variety of cooperative-learning techniques such as STAD, Jigsaw I and II, as well as team building and other elements of cooperative learning. The focus is on university-level agricultural classes but the techniques can be applied in a variety of college-level disciplines. Recommended as a brief overview of a number of cooperative-learning practices.[2]

90. Mazur, E. (1997). Peer instruction: A user's manual. Upper Saddle River, NJ: Prentice Hall.

A useful manual which details Eric Mazur's Peer Instruction procedure and provides many examples of curricular and assessment materials for use in introductory physics. Mazur uses a variety of testing strategies at the start of his classes to ensure that students have read the assigned work, then uses additional brief assessment procedures during his classes to stimulate higher-order thinking and interactive peer instruction. Mazur's manual details his use of multiple "ConcepTests" embedded within sixty-minute "Peer Instruction" lectures. Highest recommendation.

91. McEnerney, K. (1989). Cooperative learning as a strategy in clinical laboratory science education. Clinical Laboratory Science, 2, 88-89.

Describes the features of cooperative learning and how it can be applied in a college classroom. Although clinical science is the course content used in this paper the information presented can be generalized to a variety of academic disciplines. Very practical. Recommended.[1]

92. McEnerney, K. (1992, Spring). Cooperative learning: Experience in a professional curriculum. Cooperative Learning and College Teaching, 2, 2-4.

McEnerney describes the use of cooperative learning in both undergraduate and graduate clinical-science courses at a diverse campus of the California State University system. The author discusses using cooperative learning to address such issues as the special concerns of students who major in clinical science, cultural diversity, peer editing and adult learners.

93. McNeill, B. W., & Bellamy, L. (1995). Engineering core workbook for active learning, assessment & team training. Section edition. (ERIC Document Reproduction Service No. ED 384 315).

A very useful and complete workbook designed for students in Arizona State University's core engineering program. Among the content presented in this text are rationales for using small-group instruction, active-learning exercises, student-assessment materials and team-training information. Over 200 pages of practical material that could be adapted by SMET faculty in many disciplines are included. Highly recommended.

94. Miller, J. E. (1996, Spring). Learning to think like a scientist: Cooperative learning in an introductory college biology course. Cooperative Learning and College Teaching, 6, 4-7.

A description of a project-based cooperative-learning approach to teaching General Biology I and II for 100-150 students per class at Worcester Polytechnic Institute (WPI). Teams of students are assigned four projects per term and are assisted by undergraduate teaching assistants. Interactive lectures are combined with team conferencing with the assistants in an attempt to focus on having students act and think like scientists rather than simply listen to lectures. A sample project is described, dealing with the evolution of the AIDS virus.

95. Neff, G., Beyerlein, S., Apple, D., & Krumsieg, K. (1995, October). Transforming engineering education from a product to a process. Paper presented at the World Conference on Engineering Education. St. Paul, MN.

A description of Process Education in engineering courses, which is a set of principles and techniques that the authors indicate represents a paradigm shift from content mastery to problem solving and critical thinking. Among the features of the Process Education approach are the use of cooperative learning, discovery learning, journal writing and assessment. The authors provide a 13-step planning template for designing activity sheets that would be useful to instructors in any field.

96. Nurrenbern, S. C. (Ed.) (1995). Experiences in cooperative learning: A collection for chemistry teachers. Madison, WI: University of Wisconsin-Madison, Institute for Chemical Education.

A very useful workbook designed for chemistry professors. Nurrenbern offers a rationale for the use of cooperative learning, and advice on such issues as managing groups and the role of the teacher in cooperative learning. SMET faculty may be most interested in the 80 pages devoted to descriptions of a variety of cooperative tasks and exercises in chemistry. Enough detail is included to enable instructors to easily use these activities in teaching a number of SMET concepts. Highest recommendation.

97. Pence, H. E. (1993). Combining cooperative learning and multimedia in general chemistry. Education, 113, 375-380.

A description of how technology and cooperative-learning partner pairs can be combined in teaching general chemistry. The author briefly describes a sequence of instruction and reports that students' attitudes were favorably affected by the use of cooperative learning and technology (including laser disk and computer simulations). Student drop-out rates were reported as lower in classes taught using cooperative learning.

98. Roth, W. (1990, April). Collaboration and construction in the science classroom. Paper presented at the Annual Convention of the American Educational Research Association, Boston, MA. (ERIC Document Reproduction Service No. ED 318 631)

Roth argues that knowledge is a social construction and is "shared through social transactions in a community of knowers, rather than being descriptive of an absolute, knower-independent reality." He then describes his basic beliefs and central metaphors which he uses in the teaching of science. The last section of this conference paper describes specific collaborative procedures Roth uses in the teaching of physics, including collaborative learning and cognitive mapping. This paper is of particular interest to those teaching in the physical sciences.[2]

99. Schamel, D., & Ayres, M. P. (1992). The minds-on approach: Student creativity and personal involvement in the undergraduate science laboratory. Journal of College Science Teaching, 21(4), 226-229.

A clearly-written short article that describes how two biologists use a small-group cooperative technique as an alternative to more traditionally-taught lab formats. In addition to briefly describing their "Minds On" active-learning approach, the authors describe six problems in traditionally-taught laboratory instruction and how their approach represents an improvement to that format. They report that 81-92% of their students prefer the cooperative-group lab format.

[1] This citation was included in: Cooper, J. L., & Mueck, R. (1989). Cooperative/collaborative learning: Research and practice (primarily) at the collegiate level. The Journal of Staff, Program, & Organization Development, 7, 143-148.

[2] This citation was included in: Cooper, J., McKinney, M., & Robinson, P. (1991). Cooperative/collaborative learning: Part II. The Journal of Staff, Program, & Organization Development, 9, 239-247.

[3] This citation was included in: Robinson, P., & Cooper, J. (1995). An annotated bibliography of cooperative learning in higher education: Part III--the 1990s. Cooperative Learning and College Teaching.

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