Occasional Paper No. 6

Small-Group Instruction: An Annotated Bibliography of Science, Mathematics, Engineering and Technology Resources in Higher Education

James Cooper and Pamela Robinson
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Abstract

In their introduction, the authors describe and give brief answers to commonly asked questions concerning small-group instruction. The first question addresses differences between cooperative learning and other forms of small-group instruction. The second relates to research and theory in cooperative learning in higher education, especially as the technique applies to science, mathematics, engineering and technology. The third question concerns sources for addressing applications of cooperative learning, particularly in SMET disciplines. For each question, the authors identify resources in the bibliography that provide additional information for those seeking more detailed and sophisticated responses.

The authors then identify 99 resources that may be of value to SMET researchers and practitioners. They annotate each resource, often providing their own assessment of the value of each for different audiences (e.g., those new to cooperative learning, those interested in applied rather than theoretical material). This section of the bibliography is divided into four parts. The first part identifies resources related to general collegiate research and theory concerning cooperative learning. The second focuses on SMET-related research and theory concerning cooperative learning in higher education. The third section focuses on general applied work in cooperative learning in higher education, while the fourth section focuses on SMET-related applied work at the college level. A topical index is included that guides readers to specific work focused on specific disciplines (e.g., chemistry, calculus) and types of publications (e.g., meta-analyses, workbooks).
**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 that 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 that document theoretical and empirical support for the power of cooperative learning as it is used in SMET disciplines. Resources are described that 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 that may help readers get a sense of the broad range of structures implemented by practitioners in the field, structures that 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 that 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 nontechnical 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 that support 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 precollegiate level, as documented by the Johnson, Maruyama, Johnson, Nelson, and Skon (1981) meta-analysis (8) and the Johnson and 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, on student attrition, and on student attitudes. They have identified an ambitious line of future research that 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 and Brent (81) and Felder (80) in engineering, Heller and her associates
(31, 32) in physics, and M. Cooper (21, 22) in chemistry have led colleagues within disciplinary
groups by 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 that are beginning steps in what we hope will be a long-term commitment by
NSF and others not only to further assess the impact of cooperative learning within and across
SMET disciplines, but also to organize this information in order to stimulate additional research
and applied work. The present authors have recently completed a thematic paper1 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 about 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 (59) have written a general sourcebook that 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

1. Cooper, J., & Robinson, P. (in press). Small-group instruction in science, mathematics, engineering and
technology (SMET) disciplines: A status report and an agenda for the future. *Journal of College Sciences Teaching.*
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


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 new practitioners 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.


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.


A powerful and persuasive conceptual piece that 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 addresses status problems in group learning. Not an easy read for most, but well worth the effort.


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 that 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.


A powerful book that 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.


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.


A research summary that 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.


Influential meta-analysis of cooperative-learning research. A review of 122 studies (largely K-12) that 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.


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.

A good article that 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.


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.


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.


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.
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 (e.g., mathematics, science), student outcomes affected by cooperative learning (e.g., 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).

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


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; #43): (a) present concept is not satisfying to learner, (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.


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.

An examination of an adaptation of Treisman’s calculus workshop model for students at California State University, Pomona, with the following findings: (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 nonparticipants 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.


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.


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.


A 65-page report of a committee of 20 academics, leaders of industry, and public policymakers, 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.


A description of cooperatively taught chemistry labs at Clemson University that enroll as many as 2000 students per semester. Student teams work on three open-ended multistep 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. Women’s grades were 2-10% higher in cooperative labs than in traditional labs. Course dropout rate for women in the cooperatively taught labs was 13%, compared with 21% for women in traditional labs. No achievement or dropout rate differences were observed for men in the two lab formats.


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. For a similar lecture/quiz technique, see Eric Mazur’s article (#90) describing his work in physics.


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.


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.


A study that 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.


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 writing proofs 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.


A report of a program that 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.


A study of 139 nursing students at 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.

An elaboration of the Frierson (1986) article (#28). In this study, one group of students was exposed to a traditional-instruction method; another group received regular instruction plus eight hours of test-taking instruction; and 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.


Uri Treisman’s 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.


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.


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 rate 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; #66) and other cooperative-learning theorists.


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 minilecture, sample problem analysis, and collaborative problem sets that were completed during each class meeting. The traditionally taught class used a lecture method of instruction. The cooperatively taught class generally achieved at a higher level on in-class exams and 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.


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.


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 among the three grouping conditions were observed in measures of students’ perceptions of classroom environment.


A short article in which the author presents a detailed description of a cell-division lesson in a biology class for nonmajors. 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.


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.


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.”

An interesting action-research study of an introductory chemistry course for nonmajors. 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 base group member was 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 an individual grade. 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 subcomponents 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.


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.


A study of a relatively large section of a remedial (noncredit) 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).

A fascinating article arguing 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.


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.


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.

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 postcourse evaluation, and had better attendance.


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.


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.


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 of the power of small-group instruction in SMET disciplines; 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.


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.


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 that 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.


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.”


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.

A comparison of a highly structured form of cooperative learning known as STAD® 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).


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).


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.


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

2.A. General Cooperative-Learning Resources


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.


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.


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.


An outstanding complimentary chapter to the Millis (1995; #71) chapter. 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.

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

63. Forest, L. (Ed.). *Cooperative Learning.* Santa Cruz, CA: International Association for the Study of Cooperation in Education.

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.


An excellent source that 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.


A good sourcebook that 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 that identifies a variety of collaborative techniques, including 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.


A textbook chapter that 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.


An excellent workbook that 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 publications of Interaction Book, call (612) 831-9500.


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 presentation 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 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.


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. Invaluable 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.


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 diagnose and remediate students’ learning.


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 that provides busy faculty with an overview of cooperative learning in higher education. Highest recommendation.


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 that 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 that should be considered by cooperative-learning practitioners interested in enhancing long-term retention and critical thinking. Highly recommended.


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 that 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.


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 that can last many weeks. Sharan and Sharan, who popularized the technique, describe the approach and offer examples of Group Investigation within several disciplines using K-12 populations. They also discuss the history of the approach and its effects on students.

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.


An excellent short book that 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 that closely approximate the critical features of cooperative learning are described. Text includes a good reference section.

2.B. SMET-Related Cooperative-Learning Resources


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.


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.

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. Nearly all respondents (97%) reported that they would recommend the summer session to friends.


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 that 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.


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 respond to common concerns expressed by faculty members considering adoption of cooperative learning. Highest recommendation.


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.

Summary of a presentation that 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.


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.


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.


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.


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 straightforward lecture format.


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.


An article that 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.


A useful manual that 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.


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.


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.


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. Includes over 200 pages of practical material that could be adapted by SMET faculty in many disciplines. Highly recommended.


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.


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.


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.

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 dropout rates were reported as lower in classes taught using cooperative learning.


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 that 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.


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.
Topical Index to Resources

(Numbers in **bold** are especially recommended for *new* practitioners interested in applications of small-group instruction.)

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Alphabetical Listing of Resources

Bold numbers in parentheses indicate the order of resources in the annotated bibliography.


Forest, L. (Ed.). *Cooperative Learning*. Santa Cruz, CA: International Association for the Study of Cooperation in Education. (63)


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. (10)


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. (50)


