AC 2007-17: A TEN-STEP PROCESS FOR IMPLEMENTING A SERVICE-LEARNING COURSE

Mysore Narayanan, Miami University

DR. MYSORE NARAYANAN obtained his Ph.D. from the University of Liverpool, England in the area of Electrical and Electronic Engineering. He joined Miami University in 1980 and teaches a wide variety of electrical, electronic and mechanical engineering courses. He has been invited to contribute articles to several encyclopedias and has published and presented dozens of papers at local, regional , national and international conferences. He has also designed, developed, organized and chaired several conferences for Miami University and conference sessions for a variety of organizations. He is a senior member of IEEE and is a member of ASME, SIAM, ASEE and AGU. He is actively involved in CELT activities and regularly participates and presents at the Lilly Conference. He has been the recipient of several Faculty Learning Community awards. He is also very active in assessment activities and has presented more than a dozen papers at various Assessment Institutes. His posters in the areas of Bloom's Taxonomy and Socratic Inquisition have received widespread acclaim from several scholars in the area of Cognitive Science and Educational Methodologies. He has received the Assessment of Critical Thinking Award twice and is currently working towards incorporating writing assessments that enhance students' critical thinking capabilities.

Ronald Earley, Miami University

A Ten Step Process for Implementing a Service-Learning Course

Abstract

Alexander Astin, Eyler & Giles, Honnet & Poulsen, and several other researchers have indicated that service to a community adds value to the learner's educational accomplishments. (Astin, 1985, 1993; Eyler & Giles, 1999; Honnet & Poulsen, 1989). Furthermore, it is quite apparent that students learn best, when they are provided with an opportunity to utilize their knowledge to help a select community. The authors are of the opinion that service learning relieves the students of the monotony of routine classroom work and learning disengagement. The authors believe that service learning helps to rekindle the social consciousness of the student learner. The authors promote designing of service-learning programs that can make a significant impact in the area of social activism.

This philosophy has been put in to practice at Miami University. A *Senior Design Capstone Experience* has been designed in such a manner that it does not become an item that occupies a table in an engineering laboratory. Instead, it has been transformed to be viewed as a major event that brings the college, the community and the schools together to experience a technological accomplishment of young minds. Miami University considers this to be a very important service contribution to the community as a whole. The knowledge gained through this collaboration between Miami University, the community, local area high schools, industry mentors and national sponsors is extremely valuable. Miami University Seniors, the high school students as well as their mentors and sponsors experience a bliss of technological excellence. (Narayanan, 2004 e). In this presentation, the authors provide data and analysis of results as to how their techniques have impacted upon student learning.

Introduction

The service-learning opportunities at colleges and universities should be aimed at the development of the civic education of student learners; however, the service-learning course must nevertheless be focused on career preparation of the college students as well. (Narayanan, 2004 e; Honnet & Poulsen, 1989). Furthermore it must be clearly acceptable to the appropriate accreditation agencies. The *Senior Design Project* Class, which is a two semester-long course, with a total of four credit hours, can be viewed as a service learning class, depending upon the project chosen by the select student group. It contains a substantial amount of education about ethics, ergonomics, economics, sociology and liberal education principles, in addition to rigorous engineering subject matter. The student groups are encouraged to appreciate the realities of the socio-economic impact of their chosen project. In many cases, the project will have to be addressed with a strong will to succeed and necessarily require coalitions of volunteerism, industry-sponsored funding and donated resources. The objective of a select group of *Senior Design Project* students is to appreciate the aspect of service and reinforce the reality of viable ethical, ergonomic, and economic engineering design.

A Ten-step Process

Over the past several years, the Senior Design Project Course has evolved into a very powerful and productive component in the Engineering Technology Curriculum at Miami University. Experience over these years has resulted in several modifications and ultimately has resulted in streamlining the design project process to follow a smooth flow in a systematic manner. Furthermore, feedback from a variety of boards and councils was also incorporated into developing the Senior Design Project. The Engineering Technology Industrial Advisory Board, The School of Engineering and Applied Science Executive Council, Students, Staff, Faculty and Administrators have all contributed towards the successful completion of this assignment. This has resulted in a formulation of the following ten steps during the administration of a senior design / service-learning course.

1. Conduct an extensive research and document the expertise and experience of the previous student group that was involved in the project. If this has been the pioneering project, try to gather data from similar projects conducted elsewhere by other institutions. Were there flaws in their approach? Can the flaws be removed? Did they have a list of suggestions for improvement? What conclusions can we draw from their project? Was it a total success? Could it have been done better? Has the project been dated? Are we capable of utilizing modern technology to improve our success rate ?

2. Take an inventory of the talent-at-hand. Are the skills and expertise adequate to handle the project successfully ? Do we need to acquire additional human expertise? Are our sister departments willing to offer us their expertise? (Nursing, Paper Science, Computer Science for example in the School of Engineering and Applied Science). Will such an inter-disciplinary approach be beneficial to the success of the project ? Do we need different equipment or instrumentation facilities? Do we need experts from industry or commercial establishments?

3. Conduct an extensive background search that focuses on salient features of the main project and address the key issues that may arise as the project unfolds. Always have a "Plan B." Be prepared to handle contingencies. You may be very diligent in your design, planning and implementation; regardless, things may go wrong. (Example: Bridge Building Service Learning Project ---- Heavy Rains! Students just could not work! They could not pour mixed cement concrete!)

4. Develop a *Decision Analysis Matrix* that can justify the actions taken during the development of the project. You should provide four or five methods for solving the problem. In each case you should evaluate it

with chosen engineering methodologies such as safety, cost, reliability, maintenance, performance, ergonomics, cleanliness & hygiene, etc.

5. Create a Gantt *chart* that clearly defines the time-line of the project. This *Project Planning Tool* helps the students to represent the timing of tasks required in order to complete a given project. They are very simple to understand because each task takes up one row. As the project progresses, the students are required to update the chart by filling in the bars with different colors to a length proportional to the fraction of work that has been successfully accomplished on any given task. A member of the student group who is responsible for the task normally writes his or her name on a chosen column on the chart. Several software packages are available that offer help in constructing a Gantt chart with great ease.

6. Generate a *Fish-Bone Diagram* that helps the members obtain a graphical picture of the project development and keep track of its progress. These are *Cause-and-Effect* diagrams that are used to systematically organize and list the variety of different causes that can be assigned or attributed to a given problem or an effect. This diagram is extremely useful as a visual document; however, its usefulness is invaluable when a designed process goes out of control. It is extremely easy to identify *what is causing the problem* with the help of a *Fishbone Diagram.*

7. Highlight the important issues surrounding the project and the milestones that need to be achieved and attained. These issues are the results of good feasibility study, power of logic, creative thinking and sound reasoning. The issues may not be limited to engineering design or economic viability or justification of cost analysis. Students necessarily need to address various other aspects such as Ethical, Environmental or Ergonomics.

8. Design, develop and generate an instrument to assess your progress and success of your project. Questionnaires, surveys, one-minute papers, and other self-assessment tools such as the ones described in Angelo & Cross's famous book, *Classroom Assessment Techniques,* must be utilized to assess the progress of the project at suitable intervals.

9. Aspire at accomplishing T.Q.M. (Total Quality Management) TQM is the brainchild of Dr. W. Edwards Deming who is also known as the father of the Japanese post-war industrial revival. He is regarded by many as the leading quality guru in the United States. Deming's business philosophy is summarized in his famous "14 Points" that have inspired significant changes among a number of leading US companies striving to compete in the world's increasingly competitive environment. The complete list of twenty points has been listed earlier in this paper under TQM.

10. Invite external reviewers and judges to evaluate and criticize your project. Evaluation of the service by the recipient is extremely important. It must be recognized that *Civic Education* is integral part of the service learning project exercise. It is very important that this aspect of the project is assessed clearly. Several instruments are available for assessment. (Narayanan, 2004, a, b, c, d, e). The project should be designed so that the students are able to see and appreciate the value of their technical background and expertise in solving some of the problems encountered by the citizens of the local community.

In *Review of Educational Research,* published by the National Institute for Science Education of Madison, Wisconsin, Springer, Stamen & Donovan report on a meta-analysis conducted during 1998-1999. In their paper, *Effects of small-group learning on undergraduates in science, mathematics, engineering and technology,* they conclude that small-group learning promotes greater student achievement, increases retention in courses, and promotes favorable attitudes toward the course material. (Springer, Stamen, & Donovan, 1999). Sharan & Sharan also stress the importance of cooperative learning methods incorporated into the traditional classroom and recommends group investigation. (Sharan & Sharan, 1994).

Traditional methods of instruction may not be very resourceful in service learning courses pertaining to engineering disciplines. Student learning styles are completely different and instructors have to accommodate new and different learning strategies. (Schmeck, 1988). The instructor responsible for a service-learning course is charged with the responsibility of creating an active learning environment. The instructor may have to utilize some innovative modern technology to design, develop and present interactive lecture demonstrations. (Cook-off & Thornton, 1997). Herein the instructors should utilize Silverman's guide. He offers several suggestions in his famous book, *Active learning: 101 strategies to teach any subject* (Silverman, 1996).

The authors extend this philosophy to students taking service-learning courses in the discipline of engineering in general. Feedback from students indicates a sense of satisfaction, fulfillment and accomplishment. The School of Engineering and Applied Science uses several written survey instruments to obtain and analyze student responses to classroom teaching and instructor interaction (Narayanan, 2004 b). The author strongly believes that students should be provided an opportunity to state their own views and express their opinion freely. Nevertheless, it should be remembered that they are essentially required to listen to their peers and instructors in order to appreciate their viewpoints as well.

Since ENT 497/498 is a Miami University Capstone Course, the student groups are required to submit a detailed written report about the experience. In addition, the groups are required to present their findings to the faculty, peers, external reviewers

and fellow-student groups in a *Show-and-Tell* oral presentation. Finally, it is extremely important that the achievement and accomplishments of these student teams need to be assessed and evaluated. Slavin has provided us with some very useful guidelines regarding cooperative learning and achievement. (Slavin, 1994 & 1996).

Service learning has branched off to support education with more outreach programs. For example, the Wharton School of the University of Pennsylvania has embarked on a mission to educate students with a broader perspective. They are encouraging students to become more open-minded and well articulated. Their objective is to generate a new generation of effective leaders that can make a dent in the global marketplace. The undergraduate division of the school offers a course on leadership and communication operating in groups is in reality a collaboration between students and academic affairs. It aims at developing and refining leadership skills, not only inside, but also outside the classroom. Over a course of four years, the students experience a variety of skill-building workshops, leadership development program retreats, mentoring activities, etc.

Benefits of Service Learning

Assessment of the benefits of service learning should be viewed tri-fold.

1. First and foremost the students. Are the students happy and are they having a sense of accomplishment and delight ? Are they also getting a good reinforcement of their technical knowledge? Are they effectively applying their technical skills to help the citizens of their community and helping to solve their real problems? The answers to these question can be found in their Senior Design Project Notebook & Portfolio. The technical knowledge of the student groups has been successfully utilized by the high school student groups in multiple areas. Whether it be fabrication, using aluminum channels or it be programming a microprocessor chip, what students learned at Miami's engineering program has been put to efficient and effective usage. Among the benefits of service learning, one should ask the question: *"Do the students learn design better than with traditional projects?"* Students may be able to learn design aspects better because projects are much more open-ended. It is also possible that there is an increased level of commitment on behalf of the students. They may not be comfortable to start a particular service-learning project and leave it unfinished.

2. Secondly the community that they are working with. Are the members of civic community reaping the benefits? Are they satisfied? Does it make a significant dent on their quality of life ? Did they utilize the technical and engineering skills in a constructive manner ? This

again can be confirmed by the fact that the mentor of Lakota East High School, Mr. Dave Campbell, shows great interest in the continuation of Miami University's participation in the FIRST Robotic competition. Both the high school student groups and the student groups from Miami University are really excited to work as a team. As mentioned earlier, all students have a great sense of accomplishment, achievement and satisfaction. This project epitomizes student learning at Miami University's engineering program. It utilizes not only the engineering skills but also incorporates the principles and liberal education and exemplifies the spirit of Miami Plan.

3. Finally, the university: Does this fulfill the mission statement of the university? Do the faculty, staff and administrators fully support such activity? Does the administration recommend that the project be continued and expanded ? Does this help the university increase its visibility? This can be answered easily because the Department of Engineering has been very enthusiastic in supporting this project continuously over the past five years and has plans to support this in future also. Since this activity is fairly expensive, the department offers partial financial support as well. It is also obvious that the visibility of Miami University is enhanced.

Assessment

Another method of assessment would be to utilize the high-quality tools that have been developed by the IDEA (**I**ndividual **D**evelopment & **E**ducational **A**ssessment) Center. These tools have been designed, developed and tested to assess the effectiveness of teaching and administrative performance. Their on-going research program continues to gain acceptance and provides evidence to support the reliability and validity of their assessment tools and instruments.

One must recognize the fact that assessment practices throughout the country are in a state of rapid transition. The main goal is to make a difference in the quality of student learning and also to help the local civic community whenever appropriate. (AAHE Assessment Forum, 1992). Furthermore, it is important to assess this difference *and* document it. Newer assessment practices are being developed and are intended to be more authentic; that is, to involve students in the actual or simulated performance of a task (Linn, Baker, & Dunbar, 1991). Susan Brookhart also discusses the implications of the Art and Science of Classroom Assessment and stresses that instructors should not fail to notice the *missing part of pedagogy* (Brookhart, 1999). In this context, however, the author attempts to correlate Bloom's Taxonomy principles to certain aspects of service learning as appropriate (Bloom, 1956; Bloom, Hastings & Madaus, 1971).

Assessing Learning in Interactive Courses is quite complex and Clifford O. Young, Sr., and Laura Howell Young of California State University, San Bernardino, argue that a new paradigm for assessment, a learning paradigm, must be constructed to measure the success of new kinds of educational practices. Their research is based on the data collected using two survey instruments, the Instruction Model-Learning Model Questionnaire (IMLMQ) and the Student Evaluation of Teaching Effectiveness (SETE) (Young & Young, 1999). Grasha (1990) has compared traditional versus naturalistic approaches to the assessment of learning styles and comments about the benefits they offer. Grasha's 1996 book, *Teaching with Style,* offers an innovative and user-friendly guide to enhancing the teaching and learning processes. Furthermore, it provides a unique and comprehensive approach to helping college faculty in all disciplines enhance the quality of their teaching. Internally developed assessment tools are also used in assessing service learning courses (Narayanan 2007).

The authors also require and mandate that the students create a systematically organized student-service-learning course portfolio that documents every activity in its complete detail. Whether it be group discussion or an e-mail communication or cost estimating spreadsheet, it shall be found the portfolio at an appropriate place. These portfolios are gauged, evaluated, graded and assessed using a variety of rubrics and assessment tools. One of the authors has documented these in another publication (Narayanan, 2007). The importance of Course Portfolio has been stressed by various researchers (Edgerton, Hutchings, & Quinlan, 1991; Forrest, 1990; Corbin, 1994). Dr. Barbara Cambridge, Associate Dean at the Indiana University Purdue University Indianapolis [I.U.P.U.I.] is currently the Vice President of the American Association for Higher Education (AAHE) and is the Project Director of BEAMS. (Building Engagement and Attainment of Minority Students). Her unique book, Portfolio *Learning clearly* demonstrates the value of portfolio learning as readers write, revise, assess, and present themselves as thinkers and writers in their portfolios (Cambridge and Williams, 1998). Constructed around the narrative of one engaging journey to portfolio completion, this book presents a variety of writing activities, flexible assignments, and opportunities for the student learner. The author requires that the student course portfolio be submitted, eventually, as a part of the final design project report.

Conclusions

In conclusion, the authors have described the way in which service learning has been successfully utilized by a select group of students enrolled in the Senior Design Project Course at Miami University. The authors have expanded and 'stretched' the word 'service' to incorporate more than mere 'social-service.' The authors have shown that service also may be to empower young minds with technical knowledge and expertise and create an interest and enthusiasm in young high school juniors and seniors. Furthermore, the author believes that instructors can facilitate service learning by providing a metacognitive framework for the students to operate in. The term *metacognition* was used by Craig E. Nelson to signify thinking about thinking (Nelson, 1989, 1991 November). In other words,

Nelson says that to learn *how to think critically,* one must reflect on one's own thought processes. Students need to recognize that some selected ideas and theories may have distinct advantages over others, depending on the context with which they are presented to the reader. Nelson further recommends that students should be encouraged to understand and learn how to navigate through the *Perry* scheme (Perry, 1970, 1981, 1984). The scheme proposed by W.G. Perry Jr. contends that students can apply knowledge and progress with greater ease if the learners are initially provided with a rough road map of the intellectual terrain along which they can begin their journey towards life long learning (Narayanan, 2003).

Acknowledgements

Dr. Mysore Narayanan is extremely grateful to the Center for the Enhancement of Learning and Teaching and Committee for the Enhancement of Learning and Teaching for granting him the award *: Faculty Learning Community Using Academic Service-Learning Pedagogy to Enhance Learning and Civic Engagement.* Dr. Narayanan also thanks Dr. Milt Cox, Director of Center for the Enhancement of Learning and Teaching at Miami University for his valuable suggestions and guidance. The author is extremely grateful to Dr. Gregg W. Wentzell, Managing Editor for the *Journal on Excellence in College Teaching* for his invaluable input. The author also thanks Dr. Paul Anderson, Director, *Roger and Joyce Howe Center for Writing Excellence* for his valuable input.

References

AAHE Assessment Forum. (1992). *Principles for good practice for assessing students' learning.* Washington, DC: American Association for Higher Education.

Angelo, Thomas A. and Cross, Patricia K. (1993): *Classroom Assessment Techniques. 2nd Edition.* San Francisco: Jossey-Bass Publishers.

Astin, A. (1982). *Minorities in American higher education.* San Francisco: Jossey-Bass.

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

Astin, A. (1996, 1999). *Involvement in learning revisited: Lessons we have learned.* Journal of College Student Development, 40, 587-597.

Astin, A. W. (1993). *What matters in college? Four critical years revisited.* San Francisco: Jossey-Bass.

Bloom, B. S. (Ed.) (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain.* White Plains, N.T.: Longman.

Bloom, B.S., Hastings, J.T. and Madaus, G.F. (1971). *Handbook on Formative and Summative Evaluation of Student Learning.* New York: McGraw-Hill.

Boyer, Ernest L. (1990). *Scholarship reconsidered: Priorities of the Professorate.* Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Brookhart, Susan M. (1999) *The Art and Science of Classroom Assessment: The Missing Part of Pedagogy.* Washington, DC: ASHE-ERIC Higher Education Vol. 27, 87-96.

Cerbin, W. (1994). *The course portfolio as a tool for continuous improvement of teaching and learning.* Journal on Excellence in College Teaching, 5(l), 95-105.

Cambridge, Barbara L. & Williams, Anne C. (1998) *Portfolio Learning.* New Jersey: Prentice Hall.

Deming, W. Edwards. (1986) *Out of the Crisis.* Cambridge, MA: The MIT Press.

Deming, W. Edwards. (1994) *The New Economics.* Cambridge, MA: The MIT Press.

Edgerton, R., Hutchings, P., & Quinlan, P. (1991). *The teaching portfolio: Capturing the scholarship in teaching.* Washington, DC: American Association for Higher Education.

Eyler, Janet and Giles Jr., Dwight E. (1999). *Where's the Learning in Service-Learning?* San Francisco: Jossey-Bass.

Forrest, A. (1990). *Time will tell: Portfolio-assisted assessment of general education.* Washington, DC: American Association for Higher Education.

Giamatti, A. B. (1988). *A free and ordered space:* The real world of the university. New York: Norton.

Goodman, A. I., & MacNeil, C. (1999, July-August). *Collaborating with our communities.* About Campus, 4, 19-24.

Grasha, Anthony F. (1990). *Using traditional versus naturalistic approaches to assessing learning styles in college teaching.* Journal on Excellence in College Teaching, 1, 23-38.

Grasha, Anthony F. (1996). Teaching *with Style: A practical guide to enhancing learning by understanding teaching and learning styles.* Available in CD-Rom form from IATS : International Alliance of Teachers Scholars. (ISBN # 0-9645071-1-0)

Hawkins, P., & Winter, J. (1997). *Mastering change: Learning the lessons of the enterprise in higher education initiative.* London: Department for Education and Employment.

Honnet, E.P. and Poulsen, S. (1989). *Principles of Good Practice in Combining Service and Learning.* Wingspread Special Report. Racine, WI: Johnson Foundation.

Linn, R., Baker, E., & Dunbar, S. (1991). Complex*, performance-based assessment: Expectations and validation criteria.* Educational Researcher, 20 (8), 15-21.

Narayanan, Mysore (2003). *Assessment in Higher Education: Partnerships in Learning.* Oxford, Ohio. : Miami University: 23rd Annual Lilly Conference on College Teaching.

Narayanan, Mysore (2004 a). *What is Assessment? A Different Point of View.* Pomona, CA. : California Polytechnic University : 16th Annual Lilly Conference on University & College Teaching – WEST.

Narayanan, Mysore (2004 b). *A Learner-Centered Student Course Portfolio.* Charlotte: North Carolina. Proceedings of 2004 ASME Heat Transfer/Fluids Engineering Summer Conference. July 11-15, 2004.

Narayanan, Mysore (2004 c). *A Strategic Planning Process for Implementing and Improving Assessment.* Charlotte: North Carolina. Proceedings of 2004 ASME Heat Transfer/Fluids Engineering Summer Conference. July 11-15, 2004.

Narayanan, Mysore (2004 d). *Senior Design Project Report* submitted by Bryan Grody, Ming Han and Debbie Freeman. Hamilton, Ohio: Miami University Department of Engineering Technology.

Narayanan, Mysore. (2004 e). *Service-Learning and Engineering at Miami University.* 4th Annual International Conference on Service-Learning Research, Greenville, South Carolina. October 10–12, 2004.

Narayanan, Mysore (1994-2004). *Notes taken at the departmental minutes.* Oxford, Ohio and Hamilton, Ohio : Miami University, Department of Manufacturing Engineering and Department of Engineering Technology.

Narayanan, Mysore (2007). (Accepted for publication pending modifications) *Assessment of Perceptual Modality Styles.* Honolulu: Hawaii. Proceedings of 114th ASEE Annual National Conference. June 24-27, 2007.

Nelson, Craig E. (1989). Skewered on the unicorn's horn: The illusion of a tragic tradeoff between content and critical thinking in the teaching of science. In L. W. Crowe (Ed.), Enhancing critical thinking in the sciences (pp. 17-25). Washington, DC: Society of College Science Teachers.

Nelson, Craig E. (1991, November). *Fostering critical thinking across the curriculum.* Workshop presented at the 11th Annual Lilly Conference on College Teaching, Miami University, and Oxford, OH.

Perry, W. G., Jr. (1970). *Forms of Intellectual and Ethical Development in the College Years: A scheme.* New York: Holt, Rinehart, and Winston.

Perry, W.G., Jr. (1981). "Cognitive and ethical growth: The making of meaning," in A.W. Chickering and Associates, *The Modern American College: Responding to the New Realities of Diverse Students and a Changing Society*, San Francisco: Jossey-Bass.

Perry, W. G., Jr. (1984). Examsmanship and the liberal arts: A study in educational epistemology. In A. M. Eastman et al. (Eds.), The Norton reader (6th ed.) (pp. 282 - 292). New York: Norton. (Reprinted from L. Bramson [Ed.], Examining in Harvard College: A collection of essays by members of the Harvard faculty, 1963, 125-135, Cambridge, MA: Harvard University Press)

Schmeck, R. (Ed.). (1988). *Learning strategies and learning styles.* New York: Plenum Press Publishers.

Schwartzman, R., & Phelps, G. A. (2002). Beyond consumerism and utopianism: How service learning contributes to liberal arts ideals. Journal on Excellence in College Teaching, 13 (1), 57-81.

Sharan, Y., & Sharan, S. (1994). *Group investigation in the cooperative classroom.* In S. Sharan (Ed.), Handbook of cooperative learning methods (pp. 97-114). Westport, CT: Greenwood Press.

Silberman, M. (1996). *Active learning: 101 strategies to teach any subject.* Boston: Allyn and Bacon Publishers.

Slavin, R. W. (1994). *Student teams-achievement divisions.* In S. Sharan (Ed.), Handbook of cooperative learning methods (pp. 3-19). Westport, CT: Greenwood Press.

Slavin, R. W. (1996). *Research on cooperative learning and achievement: What we know, what we need to know.* Contemporary Educational Psychology, 21, 43-69.

Sokoloff, D. R., & Thornton, R. K. (1997). Using interactive lecture demonstrations to create an active learning environment. The Physics Teacher, 35, 340-347.

Springer, L., Stanne, M. E., & Donovan, S. S. (1999). *Effects of small-group learning on undergraduates in science, mathematics, engineering and technology. A meta-analysis.* Review of Educational Research, 69(1), 21-51. Madison, WI: National Institute for Science Education.

Young, C. O., Sr., & Young, L. H. (1999). *Assessing learning in interactive courses.* Journal on Excellence in College Teaching, 10 (1), 63-76.

http://www.idea.ksu.edu/

http://www.abet.org