Next Generation Principles for Enhancing Student Learning

Sudhir Mehta, Scott Danielson
North Dakota State University / Arizona State University East

Abstract

The National Science Foundation recently funded the proposal "Statics: The next generation. "This project incorporates proven pedagogical findings to improve teaching of statics, specifically, and engineering courses in general. Using past and current research, twelve "Next Generation (NG) Principles" are proposed for enhancing student learning. These principles include incorporating active cooperative learning, service learning, writing assignments, technology, high standards of learning and teaching, and a learning support system for students. These principles are being used as a basis for teaching two sections of statics at North Dakota State University (50 and 100 student enrollments) and one section of 22 students at Arizona State University East during the fall semester of 1999. This paper describes the NG principles, their implementation in these statics sections, and initial results. The fundamental intent in using NG principles is to enable high-performance student learning and encourage faculty and students to be active partners in acquiring, constructing, and transforming knowledge.

I. Introduction

Patricia Cross, a leading educator, recently indicated in her keynote address at the American Association of Higher Education's (AAHE's) 1998 National Conference that, "We have more information about learning available to us than ever before in the history of the world." Herbert Simon, a Nobel Laureate, in his plenary session at the 1997 Frontiers in Education Conference said, "Knowledge about human learning processes has developed to the point where we can do better." Smith and Waller (1997), using current knowledge about effective teaching and learning succinctly compared old and new paradigms for college teaching (see Table 1).

TABLE 1 Comparison of Old and Next-Generation Paradigms for College Teaching (Smith and Waller, 1997)

	OLD PARADIGMS	NEXT GENERATION PARADIGMS
Teaching assumption	Any subject matter expert can teach	Teaching is complex and requires considerable training & effort
Knowledge	Transferred from faculty to students	Jointly constructed by students and faculty
Students	Passive vessel to be filled by faculty's knowledge	Active constructor, discoverer, transformer of knowledge
Faculty's Purpose	Classify and sort students	Develop students' competencies and talents
Context	Competitive/Individualistic	Cooperative learning
Power	Faculty holds and exercises power, authority, and control	Students are empowered: power is shared among students and between students and faculty
Technology use	Drill and practice; substitute textbook	Problem solving, communication, collaboration

Based on this powerful testimony for improving student learning, we explored the literature with the goal of improving student learning in a basic engineering science course, statics. Consequently, we submitted the proposal "Statics: The Next Generation" to the National Science Foundation. The proposal was funded and we established and implemented core principles named Next Generation (NG) Principles in our statics classes. However, the NG principles are general and can be applied to any engineering course. First, the NG Principles are described with implementation and initial results described in Section III. Section IV concludes with discussion and conclusions.

II. The NG Principles

Using past and current research, twelve "Next Generation (NG) Principles" are proposed and being utilized for enhancing student learning. They are briefly described below.

1. Be learner-centered. One of the basic fundamentals of public speaking is to know your audience. On the same note, we, as instructors, should know our students and keep their learning at the center of our teachings. Many instructional strategies are provided in the literature to reach students with various learning styles (Felder & Silverman, 1988; Felder, 1993). It is also important that we take student intellectual ability into account as we teach. For example, a distribution of student intellectual ability at Stanford is different as compared to a community college. Correspondingly, instructional methods should consider these differences. However, being learner-centered does not mean being lenient. In fact, one of the NG Principles (#11) is to set appropriately high standards and have high expectations from students. Being learner-centered includes planning and delivering instruction such that students take more responsibility for learning and, as Smith and Waller (1997) suggest, become active constructors, discoverers, and transformers of knowledge. Finally, Angelo and Cross (1993) suggest finding out from students their expectations, backgrounds, and interests on the first day of the class and factoring that information into our teaching.

2. Show applications and relevance of course material. Our survey of over eight hundred North Dakota State University (NDSU) students, faculty, and alumni, indicates that discussing applications and relevance of subject matter is perceived as one of the important factors in enhancing student learning (Mehta & Danielson, 2000). Felder (1993) suggests "Don't jump directly into free body diagrams and force balances on the first day of the Statics course. First, describe problems associated with the design of buildings and bridges, and artificial limbs…" In our opinion, every lecture should begin with "why" students should study that topic. Real life applications and connecting the topic to other courses in the curriculum increases student motivation and attention.

3. Focus on student outcomes and critical content. Classroom materials for an individual course topic should be based on "critical content" (key points for desired student outcomes and highlighting difficult material) and not on a philosophy that "more is better" (Danielson & Danielson, 1994; Wankat & Oreovicz, 1998). This approach also aligns with NSF's initiatives for systemic change in the teaching of chemistry and mathematics, e.g., reform calculus. Felder and Brent (1999) also recommend that "If the objective relates to what the students learn as opposed to what you present, then the goal should not be to cover the syllabus but to "uncover" the most important parts of it."

4. Explain subject matter clearly. The most important instructor characteristic for enhancing student learning (as perceived by NDSU students, alumni, and faculty) is the instructor's ability to explain subject matter clearly (Mehta & Danielson, 2000). Most instructors believe their explanations are very clear (since they understand the material) but, unfortunately, the material may not be clear to students. Often students are confused by some small detail and do not comprehend the rest of the instructor's explanation (Danielson & Danielson, 1992). Hence, instructors should prepare thoroughly, use various classroom assessment methods to validate student understanding, and use peer support, e.g., cooperative learning, to improve clarity of explanations.

5. Use fair testing and grading procedures. Tobias and Raphel (1997) note that "Every faculty member knows that exams drive student behavior." Wankat and Oreovicz (1993) indicate that "Testing requires careful thought….Unfair and poorly graded exams cause students resentment, increase likelihood of cheating, decrease student motivation and encourage aggressive student behavior." The frequency of testing is also important. Wankat and Oreovicz suggest weekly or biweekly tests for sophomores and two to three tests in a semester for graduate students. They also provide suggestions on types, material coverage, administration, scoring, and grading methods for tests. We believe a higher frequency of tests discourages "binge" studying by students and provides more timely feedback to both instructors and students about student's learning.

6. Incorporate active cooperative learning into the classroom. Nearly 600 experimental and over 100 correlational studies have been conducted on the effectiveness of active cooperative learning or ACL (Johnson et. al., 1998). Meta-anaylsis indicates that ACL results in higher academic achievement ("knowledge acquisition, retention, accuracy, creativity in problem-solving, and higher level reasoning"), helps students develop more caring, supportive, relationships and greater psychological health and self esteem (Johnson et. al., 1998). Felder and Brent (1999) answer two frequently asked questions related to ACL: Can you use active learning and still cover the syllabus? (yes), and, Do active learning methods work in large classes? (again, yes). Mazur (1997) experimented with peer instruction (a form of ACL) in large introductory physics classes and reports strong success. Hake (1998) analyzed pre- and post-standardized physics exam data for over 6000 students. He found a percentage gain of physics knowledge that was twice as high for students taught with an interactive engagement method as compared to students taught using traditional lecture-based teaching. A number of resources on ACL are available on web sites at http://www2.ncsu.edu/effective_teaching and http://www.wcer.wisc.edu/nise/cl1.

7. Incorporate classroom assessment. The primary purpose of teaching is to improve student learning (Angelo & Cross, 1993). We often assume that our students are learning what we teach them, however, upon grading tests, we realize that students have not learned (see Principle #4). Both faculty and students need to monitor learning on a continuous basis and be prepared to take additional learning measures, if necessary. Classroom assessment techniques (CATs) are important tools for monitoring learning. Several CATs like the Minute Paper, Muddiest Point, and One Sentence Summary are suggested by Angelo and Cross (1993). Mehta and his colleague have also developed several classroom assessment methods for getting quick feedback (Mehta, 1993, 1995, 1997; Mehta & Schlect, 1998).

8. Incorporate service learning. Service-learning has been defined as “a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development. Reciprocity and reflection are key concepts of service-learning.” (Jacoby et. al., 1996). Service-learning has a two-fold focus: learning for the student and service to the community. Recently Eyler and Giles (1999) conducted a study of 1500 students from 20 colleges/universities about the effect of service-learning. They found service-learning impacted positively on tolerance, personal development, interpersonal development, community, and college connections. Students reported working harder, being more curious, connecting learning to personal experience, and demonstrated deeper understanding of subject matter. Service-learning is being integrated into some engineering courses, e.g., Purdue's EPICS program in Electrical Engineering (http://epics.ecn.purdue.edu/root.asp) has several courses with service-learning components. The program has now spread to Notre Dame and Iowa State.

9. Incorporate use of appropriate technology. Information technology holds great promise for enhancing the teaching and learning processes. If technology is correctly designed and implemented, it can promote active learning, address various learning styles of students, and be accessible to students either synchronously or asynchronously via the Internet or on portable media (Chen et. al., 1999). Technology has also been effectively used to provide quick feedback to students about their daily homework and quizzes (Mehta & Schlect, 1998).

10. Incorporate writing assignments. Brent and Felder (1992) indicate that writing assignments can be ideal vehicles to enhance deeper understanding of subject matter. They have provided several specific examples of writing assignments improving student creativity, critical thinking, understanding, and connectivity between newly learned and previously known material.

11. Set high standards. An instructor has a unique role of being a gatekeeper and a coach. As gatekeepers, we want to ensure students passing our courses have learned a sufficient understanding of the subject such that they can perform tasks related to that subject in their profession and/or future classes. A second reason for setting high standards is that there is direct correlation between our expectations and student achievement (*The Professor in the Classroom*, 1999). Often the more we expect, the more we get from our students.

12. Provide great learning support. This principle focuses on the instructor's roles as coach, mentor, and advocate. The *Professor in the Classroom* (1999) suggests that we must think in terms of individual students rather than in terms of the entire class. Each individual student brings to the classroom his or her own personal life experiences and abilities. Our attitude, stance, and actions should be such that each student is able to reach his or her full potential. **We must remember that we do not teach a subject, but that we teach students!** The *Professor in the Classroom* (1999) and others (Palmer, 1998 & Scmier, 1995) give a number of specific suggestions for providing superior learning support.

With this last principle, we have come in a full circle of teaching and learning, back to Principle #1 of being learner-centered by keeping student learning at the center of our teaching.

III. Implementation and Initial Results

This section gives a brief overview of our current implementation of the NG principles and current mid-semester student feedback about them. To keep the paper to a reasonable length, each principle is not specifically addressed but the general implementation process described.

The description below is based on the two statics sections at NDSU with enrollment of 50 and 100. At ASU East (with enrollment of 22), the implementation is slightly different but the basic principles are the same. For instance, the ASU East instructor does not have the technology support present at NDSU, e.g., optical scan sheet are not used, and uses a different text. In addition, the NDSU classes use a 50-minute class session and the ASU East classes are 75 minutes.

The first step in implementing the NG Principles in statics was to develop the first draft of Next Generation Lesson Plans (NGLPs). Each lesson plan covers a class period and contains expected student outcomes, suggested student preparation before class, in-class activities (including critical content topics, cooperative learning activities, and classroom assessment activities), and out-of-class activities for students. These lesson plans are designed to encourage faculty and students to be active partners in acquiring, constructing, and transforming knowledge (Mehta & Danielson, 1999).

Initial development of lesson plans was done in the summer of 1999 and they were included on the class's web page. On the first day of classes in fall 1999, the NGLPs were given to students and the NG Principles were discussed. Students' concerns, suggestions, expectations, etc. were collected. Most student comments were similar and are summarized by one example; "It seems that it is going to take a lot of work. But if it will make me a better engineer, I am ready for the challenge."

In each class period, the class proceeds in much the same way. The class begins with students grading two assigned homework problems from the text. The procedure for checking and recording grades on an optical scan sheet is discussed elsewhere (Mehta & Schlecht, 1998). Next, a reading quiz (Mazur, 1997) is given. It usually consists of two multiple-choice questions based on the reading assignment for that day's class. The homework checking and reading quiz usually takes about ten minutes. This activity is followed by a mini-lecture covering applications and theory of the day's topic. This takes about another twenty minutes (for a total of 30 minutes, thus far).

Next, students are given a "concept quiz" (Mazur, 1997), again usually two multiple-choice questions. The concept questions are designed to probe and develop a deeper understanding of the topic just discussed. First, students individually record their answers on an op-scan sheet. Then at the instructor's signal, students discuss the questions with their neighbors. After discussion, students record a new set of answers (which could either be the same or different from their first set of answers) on the op-scan sheet. Next, a verbal response from the class is obtained. This verbal response gives instant feedback to the instructor about student responses to the quiz. Then, the instructor confirms the correct response and explains the answer. This conceptual quiz process takes about four minutes (for a running total of 34 minutes).

Next, with student participation, a typical example problem is solved in class. This takes about another 10 minutes (running total of 44 minutes). Finally, an attention quiz is given (Mehta, 1993 & 1997). This quiz consists of two multiple-choice questions based on the main ideas emphasized in that day's class. This takes about two minutes (for a total of 46 minutes). The student's drop-off their op-scan sheets in a box kept near the classroom door as they leave the room.

The NDSU students are also required to write a daily journal describing their learning in each class. Suggested topics are "What are the practical applications?" and "What are the questions or things that are not clear?." The students were also requested to volunteer three hours of their time in a semester to help other statics' students during help sessions. This was explained to students as a variation of service learning, with the classroom being considered a learning community. A sign-up sheet was used by students to pick the three one-hour times during the semester that they would serve as tutors. The student volunteers were required to complete their homework before going to their help-session, thus they were prepared to help other students as needed. Something similar was attempted at ASU East but students were very resistant. As discussed below, the ASU East student body has a large segment of "commuter" students, which impacts on their availability.

Various aspects of technology are used in the course, as appropriate. A standard web page containing course syllabus, schedule, etc., is used at both institutions. Links were provided to other web sites containing on-line multi-media modules on statics topics. Lesson plans are also linked to the class schedule and the various reading quizzes, conceptual quizzes, and attention quizzes (and their solutions) are available on the web page soon after the quizzes are taken. Solutions of the exams are also posted on the web. At NDSU, a CD-ROM containing Working Model © simulations was provided in the library for student check out. A special web-based program, "DHQM" was used to provide feedback on daily homework and quizzes to both students and instructor (Mehta and Schlect, 1998). List-serves are used to send e-mail to all students, when needed. At ASU East, the CourseInfo™ software for supporting web-based courses is being used in an experimental manner.

After about nine weeks in the semester, surveys were conducted to collect student feedback on the various activities reflecting the NG Principles and student perceptions of the activities' impact on learning. These results are shown in Tables 1 through 3.

TABLE 1 Mid-semester Feedback from a Smaller Section of Statics at NDSU

Please rate the usefulness of the following activities in your learning.

Scale: A)Very useful B)Useful C) Neutral D) Not useful E)Not useful at all

Percentage responses are given below. Total number of of responses = 42.

A	B	C	D	E	A+B	Activities
62	33	5	--	--	95%	Assigning daily homework to learn the concepts taught in class
52	36	10	2	--	88	Having 10 quizzes rather than 3 tests
60	33	7	--	--	93	Providing quiz solutions immediately after the quiz
83	17	--	--	--	100	Solving a typical problem in every class
31	50	10	10	--	81	Keeping a course portfolio as a resource for the final and future classes
43	31	24	2	--	74	Making HW solutions available in ME library (Dolve 201)
19	43	36	2	--	62	Giving daily reading quizzes for enhancing student readiness
31	38	26	5	--	69	Giving daily conceptual quizzes for enhancing critical thinking
29	41	14	17	--	70	Working on conceptual quizzes in group for enhancing team work and learning
24	45	26	5	--	69	Giving daily attention quizzes for enhancing student attention
38	52	10	--	--	90	DHQM on the web for checking HW and AQ grades
40	45	14	--	--	85	PASS on the web for checking overall grade and for prediction
50	31	17	2	--	81	E-mail listserv for contacting all ME 221 students when needed
88	12	--	--	--	100	Providing a hand-out of overheads for every class
31	45	19	5	--	76	Problem solving strategy (known, find, plan, soln.) used in this class
2	26	40	29	2	28	Group projects 1, 2, and 3.
7	17	17	29	31	24	Journal writing
21	31	36	12	--	52	Volunteering help sessions at different times
26	55	19	--	--	81	Your textbook for this class
44	44	12	--	--	88	Compare your overall learning in this class compared to other classes A)Very good B)Good C)Neutral D)Poor E)Very poor
56	37	7	--	--	93	Will you take another class from this instructor? A) Definitely Yes B) Yes C)Neutral D)No E) Definitely No
27	24	20	29	--		In what range does your overall GPA (X) lie? A) $X > 3.5$ B) $3.1 < X < 3.5$ C) $2.7 < X < 3.1$ D) $2.3 < X < 2.7$ E) $X < 2.3$

TABLE 2 Mid-semester Feedback from a Larger Section of Statics at NDSU

Percentage responses are given below. Total number of of responses = 96.

A	B	C	D	E	A+B	Activities
72	26	2	--	--	98%	Assigning daily homework to learn the concepts taught in class
68	29	2	1	--	97	Having 10 quizzes rather than 3 tests
81	12	7	--	--	93	Providing quiz solutions immediately after the quiz
82	16	2	--	--	98	Solving a typical problem in every class
41	38	18	1	3	79	Keeping a course portfolio as a resource for the final and future classes
46	31	20	2	1	77	Making HW solutions available in ME library (Dolve 201)
23	40	27	6	4	63	Giving daily reading quizzes for enhancing student readiness
26	40	26	4	4	66	Giving daily conceptual quizzes for enhancing critical thinking
34	33	21	8	4	67	Working on conceptual quizzes in group for enhancing team work and learning
34	34	24	5	2	68	Giving daily attention quizzes for enhancing student attention
53	31	14	2	--	84	DHQM on the web for checking HW and AQ grades
49	37	14	1	--	86	PASS on the web for checking overall grade and for prediction
47	26	22	4	1	73	E-mail listserv for contacting all ME 221 students when needed
91	10	--	--	--	101	Providing a hand-out of overheads for every class
29	47	17	4	3	76	Problem solving strategy (known, find, plan, soln.) used in this class
8	29	34	18	9	37	Group projects 1, 2, and 3.
2	7	23	30	38	9	Journal writing
21	32	28	10	8	53	Volunteering help sessions at different times
24	54	20	2	--	78	Your textbook for this class
44	47	9	1	--	91	Compare your overall learning in this class compared to other classes A)Very good B)Good C)Neutral D)Poor E)Very poor
66	25	7	2	--	91	Will you take another class from this instructor? A) Definitely Yes B) Yes C)Neutral D)No E) Definitely No
15	33	25	20	6		In what range does your overall GPA (X) lie? A) X > 3.5 B) 3.1 < X <3.5 C) 2.7 < X < 3.1 D) 2.3 < X < 2.7 E) X < 2.3

TABLE 3 Mid-semester Feedback from a Statics Section at ASU East

Percentage responses are given below. Total number of of responses = 21.

A	B	C	D	E	A+B	Activities
71	29	--	--	--	100%	Assigning daily homework to learn the concepts taught in class
62	29	5	5	--	91	Having 7 mini-exams rather than 3 tests
62	29	10	--	--	91	Providing quiz solutions immediately after the quizzes
19	29	38	10	5	48	Giving reading quizzes for enhancing readiness for class
45	35	15	--	5	80	Giving conceptual quizzes for enhancing critical thinking
38	33	14	10	5	71	Working in groups on conceptual quizzes
19	24	38	10	10	43	Having conceptual questions on the mini-exams
52	19	24	5		71	Emphasizing the use of problem solving strategies
25	25	35	5	10	50	The textbook for this class
25	40	20	10	5	65	Compare your overall learning in this class compared to other ETC classes A)Very good B)Good C)Neutral D)Poor E)Very poor
45	35	20	--	--	80	Will you take another class from this instructor? A) Definitely Yes B) Yes C)Neutral D)No E) Definitely No
19	24	33	14	10		In what range does your overall GPA (X) lie? A) X > 3.5 B) 3.1 < X <3.5 C) 2.7 < X < 3.1 D) 2.3 < X < 2.7 E) X < 2.3

IV. Discussion and Conclusions

Impact of different activities on learning, as perceived by students, is given in Tables 1 to 3 and is mainly self-explanatory. Again, for keeping the paper length reasonable, only the key points and our concerns are discussed below.

Tables 1 and 2 indicate that, at NDSU, journal writing was not perceived to be very useful to students. Work is needed on these writing assignments to see how they can be made more effective. The service learning component and group projects need work to make them more effective for the student's learning. While students have generally perceived other activities in the Tables 1 to 3 positively, there is still room for improvement.

An initial concern in implementing the NG principles was that students would get overwhelmed with various in-class and out-of-class activities. In case students might complain about the workload and different structure of the class, the college dean and the department chair at NDSU were informed about the course structure and they both attended the first day of class. From the mid-semester feedback, it appears that students have adapted to the new structure quite well and are in favor of many of the activities.

Another concern was that we might run out of class time when conducting all the various activities. At NDSU, with previously developed technical infrastructure and previous experience teaching statics using activities like daily homework and attention quizzes, the standard syllabus is covered (or "uncovered" as per Felder & Brent (1999)) and most activities are completed without rushing through them. At ASU, the instructor is teaching statics for the first time since 1991, with a different textbook than NDSU, and without the technology support (e.g., op-scan sheets). In addition, the smaller number of class periods available (because of the 75-minute class sessions) impacts the number of topics covered. Thus, things at ASU East were comparatively more hectic in the fall semester of 1999.

In addition, we found a significant difference in student characteristics between NDSU and ASU East. At NDSU, a larger number are traditional 19 to 21 year old students and most live on or near campus. In addition, some students live on special "engineering" floors in the dormitories. At ASU East, more students are non-traditional and both non- and traditional students often live far away from campus. One way commutes over an hour long are not uncommon. This lessens the out-of-class interaction between students at ASU East. This aspect of the student cohort may affect homework and its in-class grading and review. At NDSU, most of the students seem able to solve homework problems before coming to class, apparently sorting out questions by interacting with classmates. They very rarely have questions about homework solutions. In contrast, at ASU East, students often had questions about homework solutions as many of them, we believe, do not have opportunity to work with others while doing homework. The grading component still goes well, but significant time is often devoted to answering questions on the homework.

A significant concern existed regarding instructor preparation. This concern unfortunately turned out to be valid. It takes a lot of time to prepare appropriate multi-choice questions for the different daily quizzes. It takes time to organize and prepare presentation materials so that everything can be done in the allotted time. But, once the questions and materials are prepared, it should take less time in the future. For other statics instructors, wanting to use the NG principles in statics, we plan to publish quiz questions and other instructional materials.

The most important outcome of this experiment is determining if NG Principles make any difference in student understanding of statics, retention in college, and other "soft" skills like teamwork, problem-solving, and critical thinking. Thus far, regular quiz scores in the NG sections are about the same as compared to the quiz scores in the previous years. This type of outcome, i.e., no significant improvement in regular exam scores, has been found in many studies (Hake, 1998). However, Hake does report that in classes employing interactive engagement methods, student learning "gain" as measured by standardized conceptual test scores is more than twice that of students in traditionally taught classes. The authors plan to develop a standardized concept-based test for statics.

Finally, we believe that the NG principles are based on strong pedagogical research and should be given serious consideration. Determining NG Principles' short and long term impact on students has yet to be done. With the help of the NG Principles and other pedagogies, we plan to continue to explore the frontiers of the teaching and learning universe for the benefit of our students. So, let the voyage continue!

V. Acknowledgements

This work is partially supported by the National Science Foundation (NSF) Grant No. DUE-9950358. The proposal, "Statics: the next generation" was funded by the Division of the Undergraduate Education (DUE) at the NSF under their Course, Curriculum, and Laboratory Improvement (CCLI) Program.

References

1. Angelo, T.A. & Cross, P. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers*. Jossey Bass Publisher, San Francisco, CA.
2. Brent, R. & Felder, R. (1992). "Writing Assignments: Pathways to Connections, Clarity, Creativity," College Teaching, 40(2), 43-47.
3. Cross, Patricia (1998). "What Do We Know About Student Learning and How Do We Know It?" in Proceedings of the 1998 AAHE National Conference on Higher Education, Atlanta, GA.
4. Danielson, S.G., & Danielson, E.B. (1992). Problem solving: Improving a critical component of engineering education. In: *Creativity: Educating world-class engineers; Proceedings, 1992 Annual Conference of the ASEE,* Vol. 2, June 21-25, Toledo, OH (p. 1313-1317). New York: American Society for Engineering Education.
5. Danielson, S.G., & Danielson, E.B. (1994). Teaching problem solving via non-traditional methods. In: *1994 Annual Conference Proceedings*, American Society for Engineering Education, Vol. II, June 26-29, Edmonton, Canada (p. 1675-1680). New York: American Society for Engineering Education.
6. Felder, R. & Brent, R. (1999). "FAQs-2." Chem. Engr. Education, 33(4), 276-277.
7. Felder, R. (1993). "Reaching the Second Tier: Learning and Teaching Styles in College Science Education," J. College Science Teaching, 23(5), 286-290.
8. Felder, R. & Silverman, L. (1988). "Learning and Teaching Styles in Engineering Education," Engineering Education, 78(7), 674.
9. Hake, R. (1998). "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," Am. J Phys., 66 (1), 64-74.

10. Johnson, D., Johnson, R., & Smith, K. (1998). “Cooperative Learning returns to college: What evidence is there that it works?” *Change*, July/August, 27 - 35.
11. Mazur, Eric (1997). *Peer Instruction*. Prentice Hall, NJ.
12. Mehta, S., & Schlecht, N. (1998). “Computerized Assessment Technique for Large Classes,” *Journal of Engineering Education, Vol. 87,* 2, 167-172.
13. Mehta, S., & Danielson, S. (2000). "The Scholarship of Teaching: Building a Foundation before Reaching the Pinnacle," Under review for the *Proceedings, ASEE National Conference*, St. Louis, MO.
14. Mehta, S., & Danielson, S. (1999). "Designing Next Generation Classroom Instruction," Presented at the ASEE North Midwest Section Meeting, Winnipeg, Canada.
15. Mehta, S.I. (1997). “Productive, Quick, and Enjoyable Assessment,” *Proceedings, ASEE National Conference,* Milwaukee, WI.
16. Mehta, S.I. (1995). “A Method for Instant Assessment and Active Learning,*”* *Journal of Engineering Education*, pp. 295-298.
17. Mehta, S.I. (1993). “An Attention Quiz; A Low-Tech, High Yielding Teaching Tip,” *Proceedings of the 1993 ASEE Annual Conference,* Urbana, IL, pp. 1897-1901.
18. NSF (1996). *Shaping the Future: New Expectations for Undergraduate Education in Science Mathematics, Engineering, and Technology,* Report # NSF 96-139. The National Science Foundation, Arlington, VA.
19. Palmer, P. (1998). *The Courage to Teach: Exploring the Inner Landscape of a Teacher’s Life*, Jossey Bass Publisher, San Francisco, CA.
20. Schmier, L. (1995). *Random Thoughts: The Humanity of Teaching*, Magna Publications, Madison, WI.
21. Simon, Herbert (1998). “What We Know About Learning (Keynote Address),” *Journal of Engineering Education, Vol. 87,* 4, p. 433-436.
22. Smith, Karl & Waller, Alisha (1997). “Afterward: New Paradigms for College Teaching.” In *New Paradigms for College Teaching* edited by Campbell, Wm. and Smith, Karl. Interaction Book Company, Edina, MN.
23. The Professor in the Classroom. (1999). "How to Hold High Standards and be Supportive," Master Teacher Inc. Vol. 6, No. 2, Manhattan, KS.
24. Tobias, S. & Raphael, J. (1997). *The Hidden Curriculum Part I*, Plenum Press, New York, NY.
25. Wankat, P., & Oreovicz, F. (1998). “Content tyranny,” ASEE *Prism*, Vol. 8, 2, p. 15.
26. Wankat, P., & Oreovicz, F. (1993). Teaching Engineering, McGraw Hill, New York.

SUDHIR MEHTA

Sudhir Mehta is a professor of Mechanical Engineering at North Dakota State University. He was named the 1997 North Dakota Professor of the Year by the Carnegie Foundation and has received the HP award for excellence in laboratory instruction in 1999. Dr. Mehta and his colleagues have received the best paper awards from the ASEE in 1999 and 1995. His areas of interest are enhancing student learning, measurements, controls, robotics, mechanics, design optimization, and machine vision. He has co-authored two CD-ROM’s containing hypermedia based instrumentation and communication resource modules. He has also developed innovative techniques for active learning, collaborative learning, and quick assessment. He and his colleagues have received several grants from the NSF, 3M, and HP to enhance engineering education. Dr. Mehta received the Carnot Award for the best teacher of the year, four times, from the students of Pi Tau Sigma Society. His e-mail address is mehta@badlands.nodak.edu

SCOTT DANIELSON

Scott Danielson has been an associate professor and chair of the Manufacturing and Aeronautical Engineering Technology Department at Arizona State University East (a new campus 23 miles east of the main ASU campus) since August 1999. Previously he had been at North Dakota State University where he was a faculty member in the Industrial and Manufacturing Engineering department and past chair of the Engineering Technology Department. Other responsibilities at NDSU included teaching courses in the Mechanical Engineering and Applied Mechanics Department and managing the Robert Perkins Engineering Computer Center. Dr. Danielson received the NDSU College of Engineering and Architecture’s Teacher of the Year Award for the 1995-1996 year. His research interests include effective teaching and engineering applications of geographic information systems. Before coming to academia, he was a design engineer, maintenance supervisor, and plant engineer. He is a registered professional engineer. His e-mail address is sdanielson@asu.edu.