Improving the Classroom Environment

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Abstract— **This paper summarizes effective teaching techniques identified during the "Active/Cooperative Learning III" session of the 1999 Frontiers in Education Conference in San Juan, Puerto Rico. The paper involves the perspectives of twelve experienced college teachers engaged in a roundtable discussion of "Ways to improve a classroom environment" and "Behaviors to avoid in the classroom." In this paper, those ideas are discussed and then supplemented with general advice and specific suggestions from the experience of the authors. The paper includes an historic overview of effective teaching practices and a comprehensive bibliography of related reference material. Advice presented in this paper could benefit any teacher seeking to improve classroom effectiveness.**

I. Introduction

The 1999 *Frontiers in Education Conference* was held in San Juan, Puerto Rico, November 10–13, 1999. In addition to including a variety of informative workshops and sessions devoted to engineering education, the conference provided ample informal opportunities to discuss effective teaching practice. In fact, the "Active/Cooperative Learning III" session included a roundtable discussion whereby participants identified "Ways to improve a classroom environment" and "Behaviors to avoid in the classroom." Participants' comments were compiled into two lists, and the items of those lists were subsequently grouped into three categories: basics, stance, and management.

Basics describes all items stated at the beginning of the course: exams, homework, attendance, class participation, projects, and grading policy. Stance covers the distinction between lecture, recitation, project, and other forms of course organization and includes tactics which result in better teaching. Management concerns any systematic use of non-recorded instructional vehicles. This category involves stimulating interaction in the classroom with little extra work.

II. Ways to improve a classroom environment

A variety of practices were identified on this list. Table I presents a summary of those recommendations, grouped into the categories of basics, stance, and management. This sections provides a description of those elements.

A. Basics

How are exams given? What will be their nature, frequency, and length. How many occur? What fraction of the course grade depends on exam scores? While these things are of greatest concern to students, instructors too must recognize that their own teaching experience depends on how they structure their answers. To some extent, these questions foreshadow the deeper issue: what are the educational objectives? As instructors we are seeking to convey knowledge, encourage learning ability and interest, and establish a skilled set of individuals. One way to frame that is to explicitly list all skills and basic concepts. The concept is that students will develop, become familiar with, and learn to apply, certain things by following the course. Within those specifics there are multiple levels of accomplishment. We can describe marginal or barely passing accomplishment. It can be described in words, as can outstanding achievement for the same item. A word description of a halfway point yields a valuable image of what we mean when we assign a "B" grade. For a complete range of levels of accomplishment repeat the process for the intermediates between "D" or "P", minimal, and "A+" outstanding activity, to get an idea of what is meant by grades of "A-", "B+" and "C".

The expectations about student achievement are best stated at the beginning of the course, reinforced as it progresses, and fed back to students with grades or evaluations of work items. Although not providing this type of structure may initially save the instructor some effort the consequences for both parties are severe. Even when students finish the formal goal of course completion they could be misled about their accomplishments. This is true for every type of course although it is more evident in cases where there are open-ended objectives.

B. Stance

Striking a balance between lecturing and engaging in alternative teaching techniques is an instructor's personal challenge. There are things we know that can be transmitted by direct speech. Other knowledge can be better conveyed by practice. Whatever the instructional style, flexibility, including willingness to shift from one form to another, is a useful ally.

How should an instructor handle student participation? A sincere interest in the students certainly helps. But there is clearly no best single way. Since instructors are human and students occasionally challenge authority or deliberately avoid work, dialog has risk. Nevertheless opening to questions benefits all. Those who respond grow. All benefit through strengthened learning.

Individual differences in willingness to participate by asking questions may surface. Still although the number of times an individual speaks up strongly depends on student personal qualities, a class where all are encouraged to enter into dialog is preferable.

An instructor who strives to understand his/her own learning style gains power. How does the way you learn influence the way that you teach? Do you tend to think that others see the world the way you do? Most of us do. Can you view things from a different learning perspective? What will you do to accommodate different learners? Know yourself is at the heart of success in getting to an-

TABLE I
Ways to improve a classroom environment.

Basics	Have clear expectations regarding what students are to do.
	Relate curriculum content to things currently in the news.
	Provide something – a suitable activity – for each learning style.
	Provide a clear statement of course objectives.
Stance	Encourage or explicitly require class participation.
	Draw from instructor's own experiences in lecture or discussion.
	Use student examples as teaching instances.
	Stimulate student interest – pictorial items, real versus toy problems, hands-on activity.
Management	Share the burden, e.g., select a student recorder, one for each class meeting.
	Keep assignments to the course framework – nothing over inter-quarter or holiday break.
	Distribute copies of key visuals – save on note taking; leave gaps for student completion.
	Collect students' written reactions and thoughts – including to the course objectives.

swers to these questions. An instructor with some answers has taken steps toward making teaching fun.

C. Management

Stimulating involvement in class discussion by rewarding interaction activity in the grading is effective. One way to keep track of who participates is simply to record a number of questions and comments. If nothing else this encourages attending class, being prompt, etc., since one who isn't present can't have comments/questions recorded. Since quality is also worth recording, an instructor can take time to set a value on the participation by all the students.

Course management can be by distributed means. This is particularly so through active use of email, web site, and other computer-based information. A voluntary student run web site used files created by the instructor. The student arranged organization, pointers, and frames. A student can also write down the names of speakers and those who interact by questions or comments.

Specific sources can assist students in gaining practical experience. There is little difference with regard to teaching value whether the stimulus included in a course comes from research activity, professional practice, or community service. The key desiderata are that the item be current, topical, and real world. In a related vein, student examples can also add practical material. They can lead to interesting open questions. Specific problems, technical issues, and even practice or experience can come from the students, particularly in rapidly developing fields.

There are many examples of situations where universities, consortia, and academic-industrial partnerships act to bring realistic problems into teaching situations. One such activity is the Manufacturing Engineering Education Partnership between Penn State, Univ. of Puerto Rico, and the Univ. of Washington. One purpose of that activity was to promote hands-on experience. At UCLA many students have some financial support from a federal program. The work-study employee salary costs for undergraduates employed on campus come mostly from the federal government. The annual allocation of funds to the UCLA Financial Aid Office governs the size of the program. Through it students are able to get practical experience working "for the University, governmental agencies, or for public and private non-profit organizations as defined by the Internal Revenue Service. Students employed through the Federal Work-Study Program not only provide essential services to the University and to the community, but also have the opportunity to secure positions which may relate to their educational objectives, or enable them to gain valuable work experience. "The UCLA Financial Aid Office is responsible for determining students' financial need and eligibility" [1].

III. Behaviors to avoid in the classroom

There are several forms of classroom behavior by instructors that could potentially inhibit learning. Table II presents a summary of the behaviors we recommend avoiding, again categorized as "basics'," "stance,", and "management." Primarily these negative behaviors involve treating students with little respect. From our experience, if a teacher treats the students with concern and as developing individuals, younger professionals, or simply interesting people with different experiences, it is easier to remain aware of what is best for the students. Put explicitly, such a stance helps an instructor avoid humiliating students, speaking too quickly, and engaging in non-productive verbal interactions.

A. Basics

The elements we've identified in this category include things that anyone might do occasionally, but that when repeated could interfere with learning. Two such items involve speaking too quickly and not facing the audience.

Talking rapidly imposes difficulties for all students simply because they are unfamiliar with the subject. What could seem a normal but quick exchange in a collegial context may be not understood at all by someone exposed to the material for the first time. Further, foreign dialects prevalent in today's modern society (both in terms of students with English as a second language and professors with a foreign accent) make it important to avoid speaking quickly. And, simply rephrasing material may assist discussions. When in front of a class, an instructor should

TABLE II

Behaviors to avoid in the classroom.

Basics	Avoid reading from textbooks or other sources, instead paraphrase.
	Do not delay in answering concerns or providing feedback.
	Be certain that any examination questions correspond fairly to course material.
	Avoid time-filling activity such as meaningless exercises or busy- work.
Stance	Keep expectations reasonable.
	Talk to, not down to, students.
	Never discourage students because of their mistakes; instead praise their efforts.
	Be time-conscious. Start and stop class as scheduled. Keep posted office hours.
Management	Do not rush to complete a technical topic. Also do not tell long personal stories.
	Do not dominate experiential exercises: students' activities should lead.
	Take care to expect student success. Expectations of failure, other negatives, cause harm.
	Use multiple methods, including active/cooperative learning, when possible.

strive to keep eye contact with the students.

Other basic issues involve content of the lecture and handling of questions. We recommend against reading an item verbatim from a visual prompt or a textbook. When using other sources read at most a sentence, and preferably just a key phrase. The instructor can tell the students in ordinary words what the item says and pass out a copy for them to examine. In terms of student questions, it is very important to provide some answer, even if it is just "I'll have to get back to you later about that" when students ask a question or voice their concerns. Similarly some provision for providing feedback (e.g., some idea of final grades) is necessary.

Instructors can't simply recycle old examinations. They must assure themselves that all questions correspond to the current course material. Similarly many students are self-supporting. They value their time: instructors need to do so too. That means take pains to eliminate meaningless activity. There is no place in a course for exercises that are just busy-work.

B. Stance

Immediate response is the way to produce a sense that instruction is taking place. Thus instructor use of "That is a very good question." One walks on thin ice when one asks a class to think.

Deviation from an instructional stance is also a risky endeavor. Far better to give even easily done work assignments than turn students loose on difficult, real-world subject matter. Indeed it is essential to assign work at regular intervals; collect, rate, and return the response; and ensure that assigned ratings correlate to the final course grades. Students tend to rely on a specific structural framework regarding what they must do, and how their submitted work will impact their overall academic accomplishment as shown by a course grade.

The key to a productive instructional activity is keeping realistic expectations. One way to ensure that is to befriend one's students. That doesn't mean to erase the difference between instructor and pupil. Instead it implies talking with the enrolled students. Positive, optimistic, success oriented teaching efforts, are the way to go. We continue this theme in the management section.

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C. Management

Perhaps the single most significant caution is to move from thinking in terms of classroom time to focussing on individuals. That is, keep in mind a division between time and people management issues. Our brainstorming session comments fit into those two general categories.

For timing, we agreed that it is absolutely necessary to avoid rushing a lecture to complete a technical topic. Regarding people, we know that instructors need to act so as to expect student success. The key caution is to seek to maintain an optimistic and positive attitude.

We stressed the availability of many different means for conveying information in our discussions. Class email lists, xeroxed handouts, projects and other forms of active or cooperative learning all enliven and enrich teaching and learning experiences.

IV. Conclusions

The discussion at the 1999 Frontiers in Education conference session led to a series of positive actions that can be taken to improve the classroom environment. It also highlighted several cautions. Many of the participants teach in universities. Several are in departments of computer science, computer engineering and electrical engineering. Students in those disciplines have strong competitive tendencies, frequently seek to avoid writing, and obtain less training in verbal give-and-take than those in sociology, political science and English. Some of the classroom practices recommended take students into a mode of learning that supports the writing and speaking skills. There is substantial literature pointing to the long-term career benefits for students in following some development path that aids in strengthening those abilities.

V. Resources

The bibliography provides several ways to tap into the thoughts of others about class activities. One way to begin involves investigations of learning or cognitive styles. Another is to focus on a subject area and seek out stimulating sources within it. A third approach involves reviewing material specifically geared towards improving class methods.

For the reader seeking reference material about effective ways to structure learning, books presented under the *Educational Quality* heading would be good places to start. Although there is some overlap in the items presented here, the subject of Mathematics is the special concern of citations listed under *Quantitative Thinking*, several of which are written by non-mathematicians. A reasonable case could be made that these references represent history and culture as well. Finally, citations listed under *Engineering Education* provide information which could be useful for any college teacher.

One view is that classroom environments can be improved by recognizing the changes making technological education increasingly intertwined with the general culture. Challenges to faculty for students to do more work on writing, speaking, and cooperative group activity, is one such response to that view. Another response involves international study, sometimes by an in-residence student work experience in another country. Enrichment through sources that convey the complex way that society has absorbed technical change (see [2-25]) is yet another means to create a novel classroom.

However it is done, there are many different approaches to class improvement. Useful nonengineering sources span book items such as [13-20], and professional society publications.

A. Educational Quality

Several useful references which discuss the quality of education are listed in the bibliography. A short description of their content follows:

- Stevenson and Stigler [2] indicate in *The Learning Gap* that schools function within a culture. They compare activity in the U.S. with that in Japan, China, and other countries.
- Adams in *Conceptual Blockbusting* [3] focuses on the usefulness of visual thinking.
- Tobias in *Overcoming Math Anxiety* [4] describes a division of learning styles, both quantitative and other. She continues in *They're Not Dumb, They're Different* [5] indicating that student intelligence isn't the issue, but rather some social aspects of structuring a class are.
- Deming presents quality issues (like not teaching toward tests) in *Out of the Crisis* [6].
- The Lumsdaines [7] show the power of a mathematical computer tool in *Creative Problem Solving*.
- Fisher and Ury [8] give useful lessons on cooperation in place of competition in *Getting to YES*.

B. Quantitative Thinking

In the field of Mathematics, a variety of informative references are available. Some of those references, and brief comments about each, are as follows:

- The National Council of Teachers of Mathematics compilation of *Curriculum and Evaluation Standards for School Mathematics* describes what could be required of students at all levels in the Kindergarten through High School system [9].
- Stein presents mathematics teaching reforms and ways to think about the subject in the classroom in *Strength in Numbers* [10].
- Enzensberger's *Number Devil* delights children and adults [11]. The author, a philosopher, takes a subject rarely studied and turns it into a fairy tale that became a best seller.
- The Chernyak/Rose puzzle collection *Chicken from Minsk* presents a multilevel introduction to concepts in mathematics and physics [12].
- Devlin's *Mathematics: The Science of Patterns* gives an intelligent overview of many fundamental concepts [13].
- Dunham's *Journey* takes the ordinary reader into both ideas and history [14].
- Hoffman is a writer whose *Erdos and Mathematical Truth* overview introduces political, historical and medical facts as well as ideas [15].
- Kasner and Newman's *Imagination* is a wonderful cultural grab bag [16].
- Kanigel's *Life of the Genius Ramanujan* also presents insight into India and England [17].
- Kline's *Nonmathematician* work conveys a great deal to the general reader [18].
- Beckmann's *History of Pi* puts achievements by Galileo and Archimedes into perspective [19].
- Dantzig's *Number* expresses that scientific work depends on mathematical expression [20].
- Davis's *Thread* ties together Egyptian priests and modern mathematics [21].
- Bell's *Last Problem* conveys the powerful hold a single question can have [22].
- Nelsen's *Without Words* is a strongly pictorial demonstration of mathematics [23].
- Joseph's *Peacock* explains why a European orientation is limiting [24].
- Sobel's *Longitude* describes how humans conspired to defeat the efforts of an inventive craftsman [25].
- Stark's *Number Theory* lets the reader into a world of special properties studied for millennia [26].
- Osen's *Women* portrays many hidden achievements [27].
- Gillings *Time of the Pharaohs* lets us read the words of scribes who lived millennia ago, and understand how they reckoned [28].

C. Engineering Education

Conveying unique attributes of engineering education – such as adaptation to change and applicability of knowledge to practical situations – is worth doing whatever the means. There are several worthwhile starting points for doing this. Some examples include:

• Gupta collects diverse views on the teaching process in the IEEE Press *Beginner's Guide* [29].

• Smith does something similar with emphasis on the *Innovative* [30].

• *Teaching Engineering* [31] by Wankat/Oreovicz is still useful (though out of print). It is available on the world-wide web it, should be readily found.

• Davidson and Ambrose's *Handbook* [32] is a new effort certain to be of value to beginning professors.

• Materials published by The American Society for Engineering Education (including *Prism* and the *Journal of Engineering Education*) and by the IEEE Education Society (including *IEEE Transactions on Education*) are also valuable sources. Many such references have useful web sites [33].

References

[1] "1999 – 2000 on-campus work-study employer guide", 1999, Available at www.saonet.ucla.edu/fa/workstud/common/employer_guide.asp.

[2] Harold W. Stevenson and James W. Stigler, *Learning Gap – Why Our Schools Are Failing and What We Can Learn from Japanese and Chinese Education*, Summit Books, New York, New York, 1992.

[3] James L. Adams, *Conceptual Blockbusting*, W. H. Freeman, San Francisco, California, 1974.

[4] Sheila Tobias, *Overcoming Math Anxiety*, W. W. Norton & Company, New York, New York, May 1994.

[5] Sheila Tobias, *They're Not Dumb, They're Different: Stalking the Second Tier*, Science News Books, Long Branch, New Jersey, 1994.

[6] W. Edwards Deming, *Out of the Crisis*, MIT Press, Cambridge Massachusetts, 1986, Also see www.deming.org/deminghtml/wedi.html.

[7] Edward Lumsdaine and Monika Lumsdaine, *Creative Problem Solving*, McGraw-Hill, New York, New York, 1995.

[8] R. Fisher and W. Ury, *Getting to YES*, Houghton Mifflin, Boston, Massachusetts, 1981.

[9] *Curriculum and Evaluation Standards for School Mathematics*, The National Council of Teachers of Mathematics, Inc., Reston, Virginia, 1992.

[10] Sherman K. Stein, *Strength in Numbers*, John Wiley & Sons, New York, New York, 1996.

[11] Hans Magnus Enzensberger, *The Number Devil: A Mathematical Adventure (Translated by Michael Henry Heim, Illustrated by Rotraut Susanne Berner)*, Henry Holt and Company, New York, New York, 1998.

[12] Yuri B. Chernyak and Robert M. Rose, *The Chicken from Minsk*, HarperCollins BasicBooks, New York, New York, 1995.

[13] Keith Devlin, *Mathematics: The Science of Patterns*, W. H. Freeman and Company, New York, New York, 1994.

[14] William Dunham, *Journey Through Genius: The Great Theorems of Mathematics*, John Wiley & Sons, Inc., New York, New York, 1990.

[15] Paul Hoffman, *The Man Who Loved Only Numbers – The Story of Paul Erdos and the Search for Mathematical Truth*, Hyperion, New York, New York, 1998.

[16] Edward Kasner and James R. Newman, *Mathematics and the Imagination*, Tempus Books of Microsoft Press, Redmond, Washington, 1989.

[17] Robert Kanigel, *The Man Who Knew Infinity – A Life of the Genius Ramanujan*, Simon and Schuster, first published Charles Scribner's Sons, New York, New York, 1991.

[18] Morris Kline, *Mathematics for the Nonmathematician*, Dover, New York, New York, 1985.

[19] Petr Beckmann, *A History of Pi*, Golem Press, Boulder, Colorado, 1982.

[20] Tobias Dantzig, *Number The Language of Science*, The Macmillan Company, New York, New York, 1930.

[21] Philip J. Davis, *The Thread, A Mathematical Yarn*, Harcourt Brace Javanovich, Publishers, New York, New York, second edition, 1983.

[22] Eric Bell, *Temple, The Last Problem*, Mathematical Association of America, Washington, D.C., 1990.

[23] Roger B. Nelsen, *Proofs Without Words*, The Mathematical Association of America, Washington, D.C., 1993.

[24] George Gheverghese Joseph, *The Crest of the Peacock – Non-European Roots of Mathematics*, I.B. Tauris & Co. Ltd Publishers, London UK, 1991.

[25] Dava Sobel, *Longitude – The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time*, Fourth Estate, London, U.K., 1995.

[26] Harold M. Stark, *An Introduction to Number Theory*, MIT Press, Cambridge, Massachusetts, 1978.

[27] Lynn M. Osen, *Women in Mathematics*, The MIT Press, Cambridge Massachusetts, 1974.

[28] Richard J. Gillings, *Mathematics in the Time of the Pharaohs*, The MIT Press, Cambridge, Massachusetts, 1972.

[29] Madhu S. Gupta, Ed., *Teaching engineering: A beginner's guide*, IEEE Press, New York, New York, 1987.

[30] R. A. Smith, Ed., *Innovative teaching in engineering*, Ellis Horwood, New York, New York, 1991.

[31] Phillip C. Wankat and Frank S. Oreovicz, *Teaching Engineering*, McGraw-Hill, New York, New York, 1993, Also see unitflops.ecn.purdue.edu/ChE/News/Book/.

[32] Clifford I. Davidson and Susan A. Ambrose, *The new professor's handbook: A guide to teaching and research in engineering and science*, Anker Publishing Company, Bolton, Massachussets, 1994.

[33] World-wide web sources for journals such as www.ams.org/journals/ and www.jstor.org/journals/.

[34] Allen Klinger, "Course development in computer science design", in *29th Annual IEEE/ASEE Frontiers in Education Conference*, San Juan, Puerto Rico, Nov. 10–13, 1999, Available on CD-Rom and at www.cs.ucla.edu/ klinger/fiecpaper.html.