The Conversational Classroom

William M. Waite, Michele H. Jackson and Amer Diwan
University of Colorado at Boulder
Boulder, CO 80309
{William.Waite,Michele.Jackson,Amer.Diwan}@Colorado.edu

Abstract
Concepts taught in large, lower-division computer science courses are carefully explained in standard textbooks. Thus we hypothesized that the classroom experience should not consist primarily of a restatement of those explanations by the professor. Instead, it should provide an opportunity for the students to learn through a process of conversation among themselves and with the professor. We were able to establish such a process in a sophomore-level course with an enrollment of 116 students. This change led to a doubling of the percentage of A and A- grades compared to historical values.

Categories & Subject Descriptors
K.3.2 [Computers and Education]: Computers and Information Science Education – *computer science education*.

General Terms
Design, experimentation, performance, human factors.

Keywords
Curriculum issues, course pedagogy, classroom management, CS educational research, communication skills.

1 Introduction
Why *do* we lecture to students in a lower-division computer course? The material is standard, we have selected a textbook that covers it in a suitable manner, and we have indicated the chapters relevant to the goals of the course. If students sit passively while we tell them what's important (for the test), and explain points that we think are difficult, they are not taking responsibility for their education and not making the best use of the available resources.

As part of an ongoing study of student attitudes and strategies in computer courses, we have placed trained ethnographic observers into the classroom and conducted extensive interviews of students. On the basis of the information we obtained, we hypothesized that by changing to a "conversational" classroom culture (Section 2) we could increase the students' engagement and thereby improve their understanding of the material.

We therefore conducted an experiment (Section 3) in which we attempted to change the classroom culture of an existing course while holding other aspects constant. The results were very encouraging, increasing student engagement and also improving student performance.

2 The conversational classroom
The environment we have attempted to create is one that resembles the experience of an engaged, intellectual conversation. "Conversation" as we mean it is not informal or casual, but is closer to the interaction typical in an upper-division seminar. In effective seminars, participants learn through a process of engaging other people's ideas, surfacing issues, experiencing surprise, and reflecting on their own ideas. This is a form of learning that cannot exist without conversation.

Conversation requires that we see communication in a different way: Communication does not so much carry information between students and instructors as it provides the means for creating a context in which individuals can develop and coordinate shared understandings. To illustrate: A lecture style is a linear model of instruction. Because it is not a very rich context for interaction, learning occurs through the *transmission* of information. In a conversational classroom, with a rich interaction context, students learn through *engagement* and *participation*. This perspective aligns us with learning theories that emphasize emergence and reflection, such as Weick's theory of organizing [10], and Schön's concept of reflection-in-action [8].

The techniques for supporting conversation are not remarkable in themselves. They are widely used by instructors in any number of courses. The distinction is the systematic use of the suite of techniques to create a communication environment that authentically removes the instructor as the definitive source of information. When used comprehensively, these techniques place the responsibility upon the student to engage and participate in their own learning process.

The two primary resources are (1) techniques for creating interaction, and (2) techniques for creating a sense of presence. Complementing these resources are two behaviors (persistence and commitment to emergence) that are critical to creating and sustaining the system as a whole.

2.1 Interaction
Interactivity is a measure of the extent of give-and-take within the classroom: the level of exchange between the instructor and students, and among students themselves. It refers to the extent to

SIGCSE'03, February 19-23, 2003, Reno, Nevada, USA.

which participants share the ability to shape the nature and direction of the conversation. Consequently, interaction techniques aim to increase opportunities for talk and to diversify those opportunities; however, they must be undertaken in a spirit of openness and collaboration, to co-create the conversation.

Examples of interaction techniques:

- Asking students questions about readings
- Developing opportunities for discussion, such as by identifying points in the readings and assignments and posing questions about them
- Using short (3-5) minute informal small groups to work on problems
- Using non-defensive, supportive language (not being threatened by questions and critique, demonstrating a willingness to change)
- Encouraging students to ask questions
- Having students (rather than the instructor) answer other student's questions
- Giving students sufficient time to answer, even if it means noticeable periods of silence

2.2 Presence

Presence demonstrates one's commitment to being in a conversation as it emerges, regardless of what direction it takes or what outcome it has. Presence is also a commitment to regard the other participants in the conversation as unique, as co-creators, who have equal rights and responsibilities to one's own. Presence is exemplified by a sense of connection with one another. Presence techniques create both physical presence – decreasing the distance between instructor and student or among students themselves – and also psychological presence through a sense of attentiveness and focus.

Examples of presence techniques:

- Instructor walking the aisles – physically coming closer to the students
- Instructor taking part in small group discussion
- Instructor repeating a question to be sure that it has been understood before answering it
- Calling students by name
- Referring by name to earlier student contributions (“As Jane said earlier...”)
- Not interrupting student contributions

2.3 Persistence

The techniques outlined above must be sustained in a comprehensive and systematic manner. That is, they must persist. Persistence refers to a commitment to a conversational classroom, even when that commitment is risky for the instructor (being unable to “cover” all desired material) or facing stiff resistance from students and perhaps from course assistants. Students are more likely to trust in conversational classrooms and take the necessary risks when instructors are persistent.

Important aspects of persistence:

- Consistent use of interaction and presence techniques, particularly when use of “traditional” techniques would be easier
- Continuous use of these techniques, so that they become the normal mode of operation
- Intense use, integrating interaction and presence throughout all aspects of the classroom rather than only using them at certain times.

2.4 Commitment to Emergence

Emergence is a quality of the conversational classroom, in which the actual experience is created in real time by the interactions and presence of the participants themselves. Certainly instructors do need to plan lessons to some extent, but a commitment to emergence is a willingness to modify those plans in response to the dynamics present in the classroom. A commitment to emergence is fundamental to moving away from the “transmission” classroom model. Emergence gives students the ability to shape and direct their own learning.

Important aspects of emergence:

- Student driven pacing, speeding up or slowing down depending on student feedback
- Discussion-driven lessons rather than lecture-driven lessons
- Impromptu or interlude lectures, used when there is evidence that students do not understand
- Being willing to cover material only partially rather than thoroughly
- Not imposing structure through a pre-designed presentation (e.g., PowerPoint slides)
- Taking seriously the surfacing and elicitation of student ideas, even when they are unexpected
- A willingness to be seen as unprepared for answering a question

3 The experiment

One of us (Waite) has been responsible for ECEN 2120, a sophomore course intended to introduce students to the use of a computer as a component of a larger system. About a third of the semester is devoted to understanding the architecture and assembly language of a standard processor, and the rest to using that processor and its peripheral devices to sense and control aspects of its environment. It is a five-credit course with three 50-minute classroom sessions and two 2-hour lab periods per week. Enrollment ranges between 80 and 200. A textbook [4] and extensive web site [1][9] cover the necessary concepts.

This course poses challenges to conversation. One challenge is the size of the course and the low “floor time” (time available for speaking) per student. In such a situation, techniques must be used (1) to increase floor time (such as through breakout group discussions), (2) to create a climate in which students feel welcome to speak when they wish, and (3) to engage students as *active* listeners. For students, this means giving up the anonymity of the large lecture hall and attending to the process of the classroom as well as to the technical material.

A second challenge is the level of the course. Sophomores generally have little experience with seminar courses in which the student guides the learning process; they are accustomed instead to lecture courses where the instructor provides the content. In a traditional classroom at this level, class time is the opportunity for the instructor to access students, or student attention. By contrast, in a conversational classroom, class time is an opportunity for students to access the instructor as a learning resource. Classroom techniques must help students to develop the skills needed for this type of environment.

A third challenge is the culture of computer science and engineering education, which has been recognized as emphasizing lectures, with students as receivers of knowledge [2][5][7]. Students encountering a conversational classroom are likely to resist the approach as being ambiguous, uncertain, and non-routine.

Prof. Waite had taught this course five times prior to the spring semester of 2002. The content, laboratory exercises, and examination material had varied only slightly over that period. Lectures had been conducted in the normal way: Questions were encouraged, but the bulk of the period was devoted to presenting examples and explaining concepts that experience had shown were difficult to grasp.

Nothing but the classroom style was changed in the spring semester of 2002. The usual lecture schedule, specifying the topics to be covered in each class period and the associated readings, was posted on the class web site. As usual, examinations were very similar to those of previous semesters.

A typical classroom session would begin with questions from the students about previous material or laboratory exercises. Questions about the current readings would be deferred until older issues had been resolved. Insofar as possible, Prof. Waite would elicit answers to these questions from other members of the class. At first this was not very successful, but as the students became more familiar with the material and the classroom culture developed, peers handled many of the questions.

Prof. Waite would then pose a question to the class based on the current reading. Depending on the question's complexity, he might ask for volunteers or suggest that students work with their neighbors to come up with an answer. Most of these questions involved situations in which there really wasn't a "right" answer. Thus they would engender debates in which the students sharpened their understanding of the underlying issues.

Students had the floor for approximately 50% of a typical class period. Prof. Waite did not monopolize the conversation, but rather acted as a facilitator. Even in the case of an impromptu lecture (Section 2.4), not more than 2-3 minutes would go by without students speaking.

As expected, the level of participation varied across students: Some were quite vocal, some only spoke up occasionally, and a number would be silent unless called upon. A fraction of the students simply avoided classroom sessions. Since we did not take attendance, the exact number of students who did not attend is unknown. Our impression is that it was no larger or smaller than it was in previous incarnations of the course.

4 The results

Table 1 shows measures of student performance during the six semesters in which Prof. Waite taught the course. The average and standard deviation of these measures across the five "standard lecture" semesters are followed by the measures for the "conversational classroom" semester.

Exams 1 and 2 each contribute 15% of the student's final score. The final exam contributes 40%, with written work and demonstrations in the laboratory making up the last 30%. Students are ranked according to their final scores, and the largest first differences are used to bound clusters to which the same letter grade is assigned. (Table 1 ignores + and – modifiers, although those modifiers are used in the actual grading.) Even though the letter grade cutoffs ("Lowest A", etc. in Table 1) are assigned independently each semester, they are quite consistent.

The University of Colorado at Boulder began a trial period for a "course forgiveness" policy in the spring semester of 2001. This policy allows a student to retake a course in which they have received a grade lower than C-. The grade for the first attempt remains on their transcript, but it is not counted towards their total credits or grade point average. This trial has produced a large increase in the number of students who simply decide to give up on a course. It accounts for the larger-than-normal failure rate in 2001: 4 of the 9 students failing that semester did not bother to take the final exam.

Table 1 shows that 34% of the spring 2002 students had A or A- as their final grade. 34% is more than five standard deviations larger than the historical value for the average percentage of students receiving A or A-. The percentages for the other letter grades seem to indicate that there was a general improvement in student performance. Both the C and D ranges showed lower

Table 1. Student Performance

Year	1995	1997	1999	2000	2001	Average	Std. Dev.	2002
# Students	93	128	136	126	86			116
Lowest A	77%	73%	79%	76%	76%	76%	2%	75%
Lowest B	61%	63%	66%	67%	68%	65%	3%	65%
Lowest C	45%	41%	51%	48%	53%	48%	5%	45%
Lowest D	36%	35%	47%	37%	38%	39%	5%	36%
Students with A	17%	20%	15%	13%	16%	16%	3%	34%
Students with B	42%	21%	36%	17%	12%	26%	13%	24%
Students with C	30%	50%	38%	49%	42%	42%	8%	32%
Students with D	9%	5%	7%	13%	20%	11%	6%	3%
Students with F	2%	5%	4%	6%	10%	6%	3%	6%
Exam 1 Avg.	57%	65%	57%	45%	52%	55%	7%	55%
Exam 2 Avg.	65%	52%	59%	54%	50%	56%	6%	75%
Final Exam Avg.	54%	50%	52%	49%	52%	51%	2%	56%

percentages than usual, and the percentage of students receiving F returned to historical levels in spite of the fact that the course forgiveness policy was still in effect (6 of the 9 students failing that semester did not take the final exam).

The only intentional change we made in the spring of 2002 was to replace the standard lecture presentation with the conversational classroom strategy. Nevertheless, we were reluctant to attribute the startling improvement in performance to that change. What else could have been responsible? We looked at three possibilities: The effect of the unusually high average on Exam 2, whether exams had been easier than usual, and whether we had a smarter class than usual.

4.1 The effect of Exam 2

Table 1 shows that the average grade on Exam 2 in the spring of 2002 was considerably higher than usual. It might be that this result was sufficient to account for the increased percentage of students receiving A grades. We decided to test this hypothesis by removing Exam 2 from the calculation of the final grade, and then seeing whether the results differed significantly from those of Table 1.

A program called "Gradekeeper" [3] maintains the scores for this course. It recognizes four categories of score (test, quiz, homework, and program), and allows the user to specify weights within each category. The three tests in this course are normally given weights of 150, 150, and 400 to reflect their 15%, 15%, and 40% contributions to each student's final score. In order to remove the effect of Exam 2, therefore, it was only necessary to change the specified test weights to 206, 0, and 494. This spreads the weight that would normally be put on Exam 2 between Exam 1 and the Final Exam, in proportion to their original relative weights.

After changing the weight specifications, we requested the normal report from Gradekeeper and then Prof. Waite followed his usual procedure for assigning grades. This process occurred almost a month after the actual grades had been assigned, so we believe that the two grade assignments were independent. Because the same person did them, however, the same criteria were applied in both. (In particular, the cutoff scores did not change.)

When we compared the two grade assignments, three students had moved from A to B, and three had moved from B to A. Thus the number of students receiving A's was unchanged, and we concluded that Exam 2 had not been responsible for the improved performance.

4.2 The difficulty of the exams

Table 1 shows that the average on the spring 2002 Exam 1 was consistent with historical data. We have pointed out above that it takes time to establish the conversational classroom culture in a sophomore course, and this exam is given after only 1/3 of the semester. Prior to Exam 2, there was a significant amount of classroom discussion about the issues it normally covers, and many typical problems were completely worked by the students in the process. This was apparently an effective use of time, given the Exam 2 average. The average on the final exam was also higher than expected. Although the difference is not as dramatic as that for Exam 2, it is statistically significant at the 99% confidence level.

Students in this class have access to all previous exams via the course web site [1], and are told to use them as study guides. The instructor provides no solutions to the posted exams. Normally, students will get together to develop their own solutions, and then seek the instructor or TA for feedback and help with problems.

It is very common for the instructor to reuse questions from previous exams. Usually (but not always) the numbers or wording will be changed. There are minor changes in emphasis from semester to semester that result in new questions. For example, if a specific aspect of a laboratory assignment has been emphasized because the students have had problems with it then a question about it is likely to show up on an exam. Similarly, questions that many students have gotten wrong on one exam will often be asked again (possibly in a slightly different form) on a subsequent exam. We try to keep the level of difficulty of the exams constant, and the small variance in exam grades over the five previous semesters indicates that we do a reasonable job.

The relative difficulty of two exams is a subjective judgment. Were the spring 2002 exams easier than usual? We asked three people knowledgeable about the course material to look at the exams and give us their opinions. Two of these evaluators were computer professionals from outside the university, and the third was a professor who had never taught the course.

Each respondent was provided with a complete set of all three exams from each of the six semesters listed in Table 1. All identification of the semester and year was removed from the exams, and the course web site was made inaccessible during the evaluation period. We did not tell our respondents specifically what we were looking for; we simply asked them to rank the exams within each group (Exam 1, Exam 2, and Final Exam) in order of difficulty. We did not state any criteria by which to evaluate the difficulty of an exam.

We combined the rankings provided by our three respondents in a standard way [6], and determined that the agreement among them was significant. The combined rankings indicated that the spring, 2002 Exam 1 was the easiest in its group, while Exam 2 and the Final Exam were slightly above the middle of theirs. Thus the improved performance noted in Table 1 was not due to easy exams.

4.3 Quality of students

The final question we asked was whether the observed difference in performance could be due to a class that was either smarter or better prepared than usual.

ECEN 2120 is required for all students in Electrical and Computer Engineering and also for all students in Computer Science. The curricula in the two departments are very similar, but CS students generally take the Data Structures course before taking ECEN 2120 and the ECE students do not. Data Structures is a programming course at the University of Colorado, and we hypothesized that an extra semester of programming might provide a more solid basis for good performance in this course. If this were true, then a larger-than-normal fraction of students who had taken Data Structures could lead to more students with A's.

42 of the 116 students taking this course in the spring semester of 2002 had previously taken data structures. Their grades were randomly distributed through the entire range; obviously the fact that a student had taken the Data Structures course was neither a help nor a hindrance in ECEN 2120.

Finally, we extracted the cumulative grade-point averages for all of the students in all of the six offerings of the course listed in Table 1. There was no statistically significant difference among them.

5 Conclusions

The dominant model used in Computer Science courses at the University of Colorado has been the "transmission" model, in which the professor tells the students what they should know about the material, and provides exercises that allow them to demonstrate that they have absorbed it.

This model does not engage most students. It does not re-enforce the understanding that *they* are responsible for their education. That understanding is a critical component of what the students must take away from a university. Thus we need to modify our behavior to emphasize it.

We conducted an experiment with an existing course that had a stable syllabus, a fixed set of assignments, and a set of examinations that varied little. Moreover, this course had been taught many times by the same professor. Only *one* aspect of the course – the classroom culture – was changed.

Establishing the conversational classroom culture was not trivial. It took time for the students to understand that the professor was serious about this culture, and was not going to be cajoled into the more comfortable situation where the students could sit back and be told how to do the test.

In confidential interviews, students indicated that they saw the differences in classroom dynamics, and that the model used was distinctive within the Computer Science Department. Thus the change was not simply in the professor's perception.

Student performance was significantly enhanced relative to the historical results. This enhancement was not due to simpler exams, different scoring policies, or a brighter class.

Acknowledgement

This work was supported by the National Science Foundation under grant EIA 008625.

References

[1] Computers as Components. Online. Internet. Available http://ece.colorado.edu/~ecen2120/.

[2] Frantz, P. G., Frantz, G. C. and DeWolf, J. T. Collaboration in the engineering classroom. *Journal of Professional Issues in Engineering education and Practice*. 119 (1993) 297-303.

[3] Gradekeeper. Online. Internet. Available http://ece.colorado.edu/~ecen2120/gradekeeper/.

[4] Liu, Y., and Gibson, G. A. Microcomputer Systems. Prentice-Hall, Englewood Cliffs, NJ. 1986.

[5] Margolis, J. and Fisher, A. Unlocking the clubhouse: Women in computing. MIT Press, Cambridge, MA, 2001.

[6] Moroney, M. J. Facts From Figures. Penguin Books, Harmondsworth, Middlesex, England, 1956.

[7] Ramsey, P, Rada R. and Acquah, S. Collaborative learning for computer science students. *Journal of computers in mathematics and science teaching*. 13 (1994). 377-389.

[8] Schön, D. A. The reflective practitioner: How professionals think in action. Basic Books, New York, 1983.

[9] Waite, W. M. and Simpson, R. M. The Lab and the Web: Transforming the Sophomore Experience. In *Proceedings of ASEE '96*, 1996.

[10] Weick, K. The social psychology of organizing. Addison-Wesley, Reading, MA, 1979