Gateway to Success for At-Risk Students in a Large-Group Introductory Chemistry Class

ARTICLE *in* JOURNAL OF CHEMICAL EDUCATION · JANUARY 2001

Impact Factor: 1.11 · DOI: 10.1021/ed078p252

Diana S. Mason
University of North Texas

Gateway to Success for At-Risk Students in a Large-Group Introductory Chemistry Class

Diana Mason* and Ellen Verdel
Interdisciplinary Studies, The University of Texas at San Antonio, San Antonio, TX 78249; **drdiana@swbell.net*

Overview

This study explores aspects of the development of an activity based on informal collaboration that is suitable for use in a large-group lecture situation and its effect on the academic performance of a selected group of 36 at-risk students. The targeted students were split into two groups. One group (n = 17) attended a large chemistry lecture class (n = 210) and the other (n = 19) attended a small class whose enrollment was restricted to the at-risk student population in this study. The course has no laboratory component and was designed for nonscience majors and students with a minimal background in chemistry who wish to continue a course of study in a science or science-related field. There are no prerequisites for this course.

The strength of this study lies in the number of controls. The at-risk students were from the same population of entering freshmen. The two instructors were female and relatively new to the university, but had substantial chemistry teaching experience in other settings. Each instructor presented half of the lectures in both classes, so that the same person would present a given topic to both classes. The classes met at the same time and both groups of at-risk students attended a supplemental instruction (SI) section led by the same teaching assistant (TA). To help ensure consistency of treatment, the same instructor graded all assignments and examinations from both classes. Attendance was maximized by making students individually responsible for the collaborative assignments that were scheduled on Fridays.

Focus of Study

One motivation behind this research was to find an instructional method suited to the large-group lecture that can be used during class time and truly assists students in their attempts to succeed in introductory chemistry. A second was to compare academic performance of at-risk students in the large-group lecture to that of at-risk students, selected from the same population of entering freshmen, in the special small-group section. Enrollment in the small group was restricted to students accepted into the Gateway or Success programs at The University of Texas at Austin. Both programs target students from groups that typically have high university attrition rates (e.g., first-generation students and minorities). To qualify for either retention improvement program, a student must be regularly admitted to the university and agree to participant in weekly enrichment activities (e.g., study groups, socials, private counseling sessions) designed especially for the cohort. The difference between the programs is that the Gateway (GW) program includes students from both the general population and those who participate in NCAA athletics. In this study, as in previously published studies, success rate was defined as the number of students with a grade of C or higher divided by the number of students registered in the course (*1, 2*).

Theoretical Base

Class size exceeding 100 students has been defined as large (*3*). Many freshman and sophomore classes at the university level have enrollments over 100 students, as did the targeted freshman chemistry class in this study. For a large university, lecture is an efficient and cost-effective method for delivering instruction and it is not likely to be replaced with a more effective method in the near future (*4*). Lecture is the dominant teaching style in many general chemistry courses, regardless of its effectiveness (*5, 6*). Antony and Boatsman reported that faculty of the hard sciences and faculty of four-year institutions are less likely to engage in cooperative pedagogy, which may be the preferred mode of women and Blacks (*7*). However, simply attending chemistry lectures may provide little in the way of substantial learning simply because the lecture does not actively involve students in learning (*8*).

Informal instruction was reported to significantly increase retention by students in first-year physics (*9*). Research has also compared the effects of the traditional lecture-only format with both unstructured and structured cooperative models in general chemistry (*1*). In that study, both cooperative models were more effective in generating student success than the less interactive lecture class, which also had the highest noncompletion rate. Cooper listed as advantages of cooperative learning that students (i) take responsibility for their own learning in an active manner, (ii) are apt to attain higher-order thinking skills, (iii) have increased retention rates, and (iv) realize more positive attitudes toward the subject matter (*4*). She recommended that students in a large-group lecture be allowed to form their own ad hoc groups of 2–4, suggesting that the most successful groups were usually diverse with respect to gender, ethnicity, and ability. Francisco, Nicoll, and Trautmann also suggested the use of informal groupings (*6*). From interviews with their students, they found that students felt the lecture format was useful, but preferred the cooperative situations because it enabled them to clarify certain important points. Other studies indicate that interactive instruction and cooperative/collaborative learning models may reduce misconceptions and be beneficial to the academic success of students at the university level in chemistry and other areas (*10–19*).

Class size may also contribute to students' academic success. Some researchers report that large class size is a detriment to learning (i.e., smaller classes improve student learning) (*20–22*). However, one study found that class size had minimal effect on students' achievement (*23*). According to a report by Toby, students generally prefer small classes and appear to learn more in them (*3*). Other researchers report that large classes have a negative influence on student attitude (*24*).

Aronson identified several keys to successful instruction in a large lecture class (*25*). These include making the students feel as though they are active participants in the class, incorporating teaching assistants into the learning process, and being well prepared. Gleason suggested that creating a supportive climate based on enhanced communication between faculty and students improves the negative environment generally associated with large classes (*26*). Also, supplemental instruction (SI) has been reported to give students (especially those considered to be at risk) academic advantages (*27–34*). All these suggestions were utilized in this study.

An exhaustive search of an electronic database yielded only 40 articles concerning the relationships between success of minority students and the study of chemistry. Of these only three were marginally relevant to our research. Reitz and McCuen utilized peer-assisted learning (PAL) to improve the retention and performance of minority students (*2*). Sixty-nine percent of the interviewed students said the small-group discussion sections that met three hours per week were beneficial to their success. Comparison of the success rate (grade of A, B, or C) of students who had been tutored with that of those who had not received additional instruction indicated that tutoring did contribute to improved grades (*2*). Prior achievement and motivation strongly contributed to science achievement for African Americans and Hispanic Americans in a study by Garcia, Yu, and Coppola (*35*). These researchers suggested that a strong secondary program for promoting a direct learning strategy and student motivation was a good way to address the ethnic and gender gaps in science achievement.

Design and Procedures

The Gateway and Success programs were established by The University of Texas at Austin (UT) to help students who traditionally have high attrition rates to succeed academically and remain enrolled and on track for completion of graduation requirements within five years. Included in this at-risk population are minority students and student athletes. These two groups were targeted because of their typically high D, F, and withdrawal (W) rates in many courses, especially the sciences. All participants must be regularly admitted freshmen. Participation in the program is voluntary and students must decide to take part before matriculation. Both programs include periods of supervised study, attendance is closely followed by the instructors of designated classes, and each student cohort attends special classes dedicated to the attainment of basic study skills.

In this study 36 students (33 from the GW program and 3 from the Success program) were split into two groups. Nineteen (16 GW and the 3 Success) were placed in a small lecture class whose enrollment was restricted to these students. The remaining 17 GW students were placed in a traditional large-group lecture class (n = 210). All GW and Success students were enrolled through the Office of Student Affairs. Counselors were informed of the study and attempts were made to balance the groups for gender, ethnicity, and background variables such as SAT scores and size of the hometown high school.

To the extent possible, variables that could distort the results were controlled. Adjacent classrooms were utilized. Both classes met from 8 to 9 a.m., MWF. Lectures were equally split between the two female instructors, and the same instructor taught the same topic to both classes. This was accomplished by having one instructor lecture on one topic to the large group on Monday while the other lectured on another topic to the small group; each instructor then repeated her lecture for the other group on Wednesday. Therefore, because we wished to have the same lecture information presented to both classes by the same instructor, the order of topics varied. However, precautions were taken to ensure that the order of lessons did not interfere with the scope of the course. On Fridays, students worked on problem sets and both instructors as well as all teaching assistants were available for questions. The order of the topics and which instructor would teach what topic were established before the beginning of the fall semester to ensure equal lecture time by both instructors and appropriate topic sequencing. Twice during the semester the small and large groups were combined because of the nature of the lecture (once was for a videotape on the periodic table; and the other time was for a special demonstration day on balancing equations).

All student assignments (problem sets and exams) were graded by one of the two instructors assigned to the courses. The majority of the Fridays during the semester were devoted to in-class collaborative assignments, which constituted 40% of the student's final grade. There were three examinations (midterm, end-of-term, and a comprehensive final), each of which counted for 20% of the final grade. SI sections were established for both at-risk student groups. These sections met from 8:30 to 9:30 a.m. on Tuesday for the large-group GW students and on Thursday for the small-group students. The same TA taught both SI sections. Individual study skills and content mastery were the major foci of these sessions.

The nature of the 12 informal collaborative problem sets was as follows. All questions emphasized both the conceptual and the quantitative nature of chemistry. As frequently as possible UT trivia were incorporated into the questions. For example, conversion of yards gained to meters gained by a former UT athlete might be a quantitative question. Or, students might be asked to calculate the heat of combustion related to firing Smokey, the UT cannon. Again, students might calculate the density of Big Bertha, the infamous "radioactive" bass drum given to UT by the University of Chicago after the end of the Manhattan Project.

Except for the two take-home problem sets, the 10-question problem sets were to be completed by each student individually during the 50-minute class period. Students could ask for assistance from one of the instructors or TAs assigned to the courses (usually one instructor and one TA were in each class during this time). The large-group lecture class was also attended by two additional graduate students, who helped students with their problem sets on Fridays and thus lowered the student–TA ratio. The instructors alternated between the adjacent classes at least once on Fridays. Students were encouraged to form informal collaborative groups, but they could also work alone. They were allowed to consult their textbook (Zumdahl's *Introductory Chemistry*) or use any other text or lecture material they chose. However, each student received a grade reflective of his or her individual performance, *not* of any collaborative effort. All problem sets were collected at the end of the time allotted, graded over the weekend by the same instructor, and returned to the students by Monday morning before class at 8 a.m.

Results

Mean SAT scores are reported in Table 1. No significant differences between the small lecture class (GW/Success group) and the GW members who attended the large lecture class were detected at the alpha level of .05 (V-SAT, p = .6475; M-SAT, p = .7663; total SAT, p = .7395). For comparison, the available SAT averages for students not considered to be at risk are also reported in Table 1.

Class averages were calculated for 229 students; 17 students failed to complete the course. Averages were computed for the GW/Success students in the small- and large-group lectures and compared to the averages of the remaining 193 students in the large lecture class (Table 2). No statistically significant differences were seen between the course averages of students in the GW program, regardless of whether they were in the small (p = .5482) or large (p = .1461) lecture. Likewise, there was no statistical difference between the final averages of the at-risk students and of the other students in the class (p = .1158). The letter grade distributions for all GW students are presented in Figure 1. No student withdrew from either GW class; the three failing grades were assigned to students who attended the small GW lecture.

Table 1. Mean SAT Scores of Student Groups

Students	n	Test Score		
		V-SAT	M-SAT	Total SAT
At-risk small group	19	437	462	899
At-risk large group	17	416	462	878
Other students	165	496	575	1071

Table 2. Class Averages for Student Groups

Group[a]	n	Average	t value
Small GW/Success	19	70.6	.5482
Large GW	17	75.5	.1461
All GW/Success	36	72.9	.1158
Not at risk	193	77.0	.5754
All students	229	76.4	—

[a]GW indicates Gateway program; Success indicates Success program.

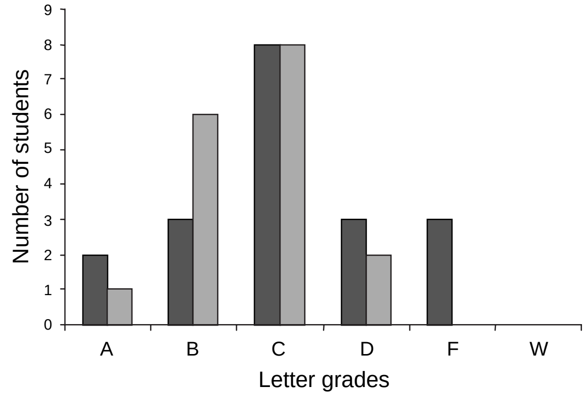

Figure 1. Grade distributions for students in at-risk groups: small-group lecture (light bars) and large-group lecture (dark bars).

Discussion and Conclusions

The students were asked to rank 10 pre-selected aspects of the course (e.g., lectures, in-class problem sets, SI sessions, exams, helpfulness of TAs outside of class) from 1 (liked best or most beneficial) to 10 (liked least or least beneficial). The sample from the large group (159 surveys collected) ranked the in-class problem sets first, and 16 students from the smaller class ranked the in-class assignments second behind their favorite/most helpful part of the course, the lectures. It is interesting that students in the small GW/Success class found the small-group lecture to be their favorite part of the course, whereas the in-class problem sets (which were used not only to reinforce concepts but also to create a situation that allows large-group lectures to seem smaller) were the favorite in the large class.

Are small-group situations more advantageous academically than large-group lectures for Gateway/Success students enrolled in chemistry classes designed for the nonscience major at the university level? If only the class averages are evaluated the answer is “No”. However, this may not be the only reason for creating small cohorts of students. The Gateway/Success students in both classes finished at the average level, C, according to the criteria for success in this course, as did the non-GW students. A greater issue is the retention rate. No GW or Success student withdrew from this course. However, 17 (8.1%) from the non-GW/Success group withdrew.

Another question that must be addressed is obvious. Why did GW students in the large lecture outperform the students from the small group on the average? Perhaps this is due to the nature of the collaborative assignments used as the Friday problem sets. During the lecture period students were encouraged to seek help from any source they chose (i.e., a person or written information). The students in the small class had only the opportunity to collaborate with other at-risk students, whereas the GW students in the large-lecture section had opportunity to talk to a more diverse (and possibly more knowledgeable) population of students. The effects of “scaffolding” have been well documented by another education researcher (*36*). This *Journal* continues to publish articles documenting the effects of student-centered learning, collaborative/cooperative learning, and supplemental instruction (*37–40*). The opportunity for the GW students in the large lecture to collaborate with students who might have more prior knowledge and better academic skills in chemistry was greater than for their peers in the small group. The data do not support enhancement of academic performance of these at-risk students who attended the smaller class. However, as seen in this sample, the value of targeting special groups of at-risk students may be that 100% of this cohort completed the course.

Literature Cited

1. Dougherty, R. C.; Bowen, C. W.; Berger, T.; Rees, W.; Mellon, E. K.; Pulliam, E. *J. Chem. Educ.* **1995**, *72*, 793–797.
2. Reitz, N.; McCuen, S. American River College Beacon Project

Student Catalyst Program: Peer Assisted Learning; Annual Report, 1992–93; ED365383; ERIC Clearing House on Higher Education: Washington, DC, 1993.
3. Toby, S. *J. Chem. Educ*. **1998**, *65*, 788–790.
4. Cooper, M. M. *J. Chem. Educ*. **1995**, *72*, 162–164.
5. Spencer, J. N. *J. Coll. Sci. Teach*. **1993–1994**, *23*, 159–161.
6. Francisco, J. S.; Nicoll, G.; Trautmann, M. *J. Chem. Educ*. **1998**, *75*, 210–213.
7. Antony, J.; Boatsman, K. C. Defining the Teaching–Learning Function in Terms of Cooperative Pedagogy: An Empirical Taxonomy of Faculty Practices; presented at ASHE Annual Meeting; ED375725; ERIC Clearing House on Higher Education: Washington, DC, 1994.
8. Birk, J. P.; Foster, J. *J. Chem. Educ*. **1993**, *70*, 180-182.
9. Wolfson, M. L. *J. Coll. Sci. Teach.* **1977**, *6*, 36–37.
10. Basili, P. A.; Sanford, J. P. *J. Res. Sci. Teach.* **1991**, *28*, 293–304.
11. Beckwith, D. *Collegiate Microcomp.* **1993**, *11*, 70–74. Also: Creative Group Problem Solving: An Empirical Taxonomy of Faculty Practices; presented at ASHE Annual Meeting; EJ464295; ERIC Clearing House on Higher Education: Washington, DC, 1993.
12. Bowen, C. W.; Phelps, A. *J. Chem. Educ*. **1997**, *74*, 715–719.
13. Carroll, E. R. *J. Bus. Tech. Commun.* **1991**, *5*, 285–299.
14. Kurfiss, J. *AAHE Bull.* **1987**, *39* (8). Also: The Reasoning-Centered Classroom: Approaches That Work; ED283445; ERIC Clearing House on Higher Education: Washington, DC, 1987.
15. Lemke, T. L.; Basile, C. *Am. J. Pharm. Educ.* **1997**, *61*, 351–358. Also: An Odyssey into Cooperative Learning; EJ561267; ERIC Clearing House on Higher Education: Washington, DC, 1997.
16. Penhale, S. J. *Sci. Tech. Lib.* **1997**, *16*, 69–87. Also: Cooperative Learning Using Chemical Literature; EJ562992; ERIC Clearing House on Higher Education: Washington, DC, 1997.
17. Phelps, A. J. *J. Chem. Educ*. **1996**, *73*, 301–304.
18. Robinson, W. R.; Niaz, M. *Int. J. Sci. Educ.* **1991**, *13*, 203–215.
19. Verdel, E. F. O. Collaborative Learning and Computer-Based Instruction in Introductory Chemistry. Ph.D. Dissertation, The University of Texas at Austin, Austin, 1996.
20. Brown, B. J. *J. Geog.* **1994**, *93*, 132–135.
21. Knight, W. E. The Effect of Class Size in English 10000: “Introduction to College English” on Student Grades in English 10001: “College English I” in the Kent State University Regional Campuses; ED335100; ERIC Clearing House on Higher Education: Washington, DC, 1991.
22. Raimondo, H. J.; Esposito, L.; Gershenberg, I. *J. Econ. Educ.* **1990**, *21*, 369–381.
23. Williams, D. D.; Cook, P. F.; Quinn, B.; Jensen, R. P. *Res. Higher Educ.* **1985**, *23*, 307–318.
24. Gunter, R. E.; Gunter, G. A. The Effect of Class Size on Students’ Attitudes toward Computers; ED382187; ERIC Clearing House on Higher Education: Washington, DC, 1994.
25. Aronson, J. R. *New Direct. Teach. Learn.* **1987**, *32*, 31–37.
26. Gleason, M. *Coll. Teach.* **1986**, *34*, 20–24.
27. Ainsworth, L.; Garnett, D.; DaNay, P.; Shannon, S.; Ripperger-Suhler, K. *New Direct. Teach. Learn*. **1994**, *60*, 23–29.
28. Arendale, D. R. *New Direct. Teach. Learn.* **1994**, *60*, 11–21.
29. Kenny, P. A. Effects of Supplemental Instruction on Student Performance in a College-Level Mathematics Course; ED347874; ERIC Clearing House on Higher Education: Washington, DC, 1989.
30. Kenney, P. A.; Kallison, J. M. Jr. *New Direct. Teach. Learn.* **1994**, *60*, 75–82.
31. Lockie, N. M.; Van Lanen, R. J. *New Direct. Teach. Learn.* **1994**, *60*, 63–74.
32. Martin, D. C.; Blanc, R. A. *New Direct. Teach. Learn.* **1994**, *60*, 83–91.
33. Van Lanen, R. J.; Lockie, N. M. *J. Coll. Sci. Teach.* **1997**, *26*, 419–423.
34. Warren, B. Z.; Tonsetic, R. *J. Staff Prog. Organiz. Devel.* **1997–1998**, *15*, 47–54. Also: Supporting Large Classes with Supplemental Instruction (SI); EJ567773; ERIC Clearing House on Higher Education: Washington, DC, 1998.
35. Garcia, T.; Yu, S. L.; Coppola, B. P. Women and Minorities in Science: Motivational and Cognitive Correlates of Achievement; ED359235; ERIC Clearing House on Higher Education: Washington, DC, 1993.
36. Vygotsky, L. S. *Educational Psychology*; St. Lucie Press: Boca Raton, FL, 1926/1997.
37. Webster, T. J.; Hooper, L. *J. Chem. Educ.* **1998**, *75*, 328–331.
38. Landis, C. R.; Peace, G. E. Jr.; Scharberg, M. A.; Branz, S.; Spencer, J. N.; Ricci, R. W.; Zumdahl, S. A.; Shaw, D. *J. Chem. Educ.* **1998**, *75*, 741–744.
39. Browne, L. M.; Blackburn, E. V. *J. Chem. Educ.* **1999**, *76*, 1104–1107.
40. Herron, J. D.; Nurrenbern, S. C. *J. Chem. Educ.* **1999**, *76*, 1354–1361.