Chem-2-Chem: Peer Tutoring and Mentoring Creates a Supportive Learning Environment That Enhances Achievement in a General Chemistry Course

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Abstract

A Chem-2-Chem Program providing a supportive learning environment was designed to instill positive study attitudes and self-confidence to help students achieve successful General Chemistry course outcomes. This program was developed to increase student retention by providing a peer-led personalized and individualized learning experience to address their academic and emotional needs in a holistic way. Some students enrolled in chemistry courses at the Cayey University College (CUC) of the University of Puerto Rico (UPR) participated in this program over the past two and a half years. Data was collected from student questionnaires as well as official class lists of all General Chemistry course sections with the final grade for each student. Results over the past two years, show a significant increase in satisfactory course outcomes (final grades of A, B, or C) and indicate the development of positive attitudes among program participants when compared with non-participants.

Introduction

Cayey University College (CUC) is a small undergraduate campus of the University of Puerto Rico (UPR). For the first semester of the 1999 – 2000 academic year, CUC–UPR had a total enrollment of 3,972 of which 1328 (33.4%) were enrolled in science and mathematics programs in the natural sciences and education. A Chem-2-Chem Program was designed and implemented at CUC–UPR to provide a supportive learning environment for General Chemistry students. In addition to providing academic assistance, the Program develops student self-confidence and positive study attitudes necessary to help them achieve successful Chemistry course outcomes. Strengthening basic science courses is a first step to achieve a long-range improvement in science education and increase the number of Puerto Ricans in science careers.

The Chem-2-Chem Program takes advantage of an underutilized resource – undergraduate students as mentors and tutors. Working definitions of the concepts of tutoring and mentoring as used in this Program are given in Table 1. This two pronged approach of academic tutoring and emotional personal mentoring enhances student achievement by providing a stable and secure learning community consisting of upper level student leaders in the role of tutor and mentor and students enrolled in the General Chemistry course. Both tutors and tutored students share academic and personal development experiences that enrich their university life. This endeavor promotes autonomous learning (Black,) and strengthens the quality of education by creating support networks that develop self-esteem, individual study and communication skills, and teamwork promoting meaningful relationships related to the

learning environment.

The transitions encountered by students during their freshman year, after leaving the family and school support network, are critical. For these students, the intensity of academic work and their newly found independence requires an adjustment for them to feel at ease in the university environment. Retention of entering college freshmen students until successful completion of all graduation requirements is a complex issue impacted by many factors. Decreasing attrition and increasing retention rates is a challenge faced by all colleges and universities and is an important element in maximizing the use of limited educational resources. Many models of student retention have been proposed over the past thirty years (Spady, 1971; Tinto, 1975; 1987). According to Tinto's classical model of retention, student retention and success requires an integration between the cognitive and affective needs of the student and the academic and social environment of the institution (Daly, 1988).

One way for the institution to decrease attrition and increase retention is to meet these needs of the students by providing the appropriate environment. According to Vygotsky's cultural and cognitive theory of development, cognitive skills and thinking patterns are determined in the social and cultural contexts of the learning environment (Vygotsky, 1962; 1978). According to this theory, the Zone of Proximal Development is the difference between students' independent problem solving capabilities and their potential with guidance or collaborative assistance. Recent pedagogical research has shown that students learn better through social interaction (Spencer, 1999). The creation of student interest groups providing a caring, student-centered environment helps students to relate with their peers in meaningful ways and have positive interactions with faculty. The affective needs of the students must be met to put them on the road to success.

From 1995 to 1997, between 42% to 51% of students enrolled in the General Chemistry course at Cayey University College either failed or dropped the course ("F" or "W"). Studies were unsuccessful in identifying student risk factors correlated with their failure in this course. These studies did not show a correlation between the index used for student admissions (The IGS is based on College Board Exam Scores and High School Grade Point Average) and success in the General Chemistry course. It was found that the majority of CUC students have IGS scores that are below the minimum value found to be necessary to pass the course (J. Pardo, unpublished results). The Chem-2-Chem Program was proposed as a solution to increase student success outcomes without sacrificing course quality, expectations, and content.

The main objective of the Chem-2-Chem Program focuses on providing General Chemistry students with emotional and academic support to enable them to increase comprehension in basic courses and improve course performance. Other objectives include providing students with a support network for adaptation to university life and helping them to develop the necessary skills to succeed in science careers. Upper level student tutors serve as role models for student participants and the program increases interactions between students (tutors and participants) and professors.

Chem-2-Chem can serve as a useful model program to turn the tide towards a more "humane" education for other gatekeeper courses at large and small institutions. This program can help introduce a "small college culture" to institutions of all sizes. Chem-2-Chem can be used to change student perception that chemistry is unapproachable and break the psychological barriers that make students avoid science careers. We believe that this Program will increase the probability that students complete their Bachelors degree and continue post graduate studies in science.

Table 1: Definitions of Tutor and Mentor
Mentor – Someone who takes an active interest in shaping and guiding a less experienced person. The relationship between a MENTOR and MENTEE developes from the Mentor's ability to be a CARING, CONCERNED, COMMITTED individual (Skinner, 1993).
Tutor – Someone who actively participates in the academic development of other people, helping them to understand concepts and deepen their learning.

Table 1: Definitions of Tutor and Mentor. Explanation of the concepts of Tutor and Mentor as used in this Program.

Methods

Program Structure and Organization:

Personnel associated with the Chem-2-Chem Program include directors, an administrator, student mentors, and student participants. An organizational chart illustrating the relationships between program personnel is shown in Figure 1. The directors are professors with a commitment to excellence in education. They are responsible to coordinate the smooth functioning of the entire program and carrying out assessment to indicate improvement (Table 2). The administrator is responsible for accounting and secretarial support (Table 2). The student mentors are advanced students, preferably chemistry majors with a cumulative grade point average (GPA) greater than 3.00 who have passed the General Chemistry course with an "A" or "B" and have excellent recommendations from their chemistry professors. The selection of the student mentors is also based upon an interview. They are paid for seven hours a week to serve as program mentors: three hours in course attendance, three hours in tutoring and mentoring, and one hour in staff meetings (Table 3). The tutored students receive an orientation at the beginning of the semester. They are responsible to attend the support sessions according to the assigned schedule (Table 2).

Directors, Administrator, Student Mentors, and Student Participants:

Figure 1: Organizational chart illustrating relationships between program personnel

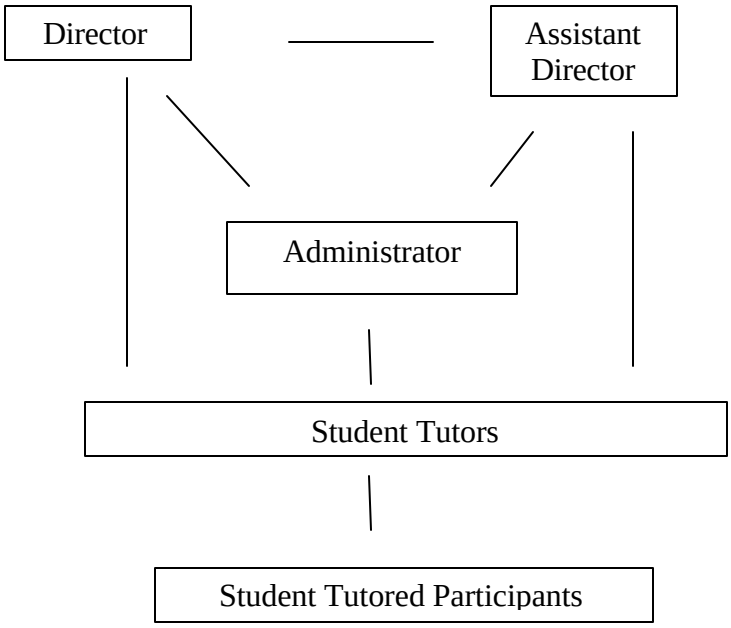

Figure 1: Organizational Chart for Chem-2-Chem Program. Relationships are denoted for major personnel associated with the Chem-2-Chem Program.

Table 2: Responsibilities of Key Personnel: Directors, Administrators, and Participants

Directors
Supervise personnel
Coordinate activities
Interview and select student tutors
Serve as mentors and facilitators
Direct weekly staff meetings
Encourage interactions between professors and students
Advise special cases
Prepare reports and presentation

Administrator
Record attendance
Prepare payroll forms
Assist in collecting and tabulating data

Student Tutored Participants
Attend and participate in tutoring sessions
Participate actively in the study group ("learning community")
Do home work
Establish relationships

Table 2: Responsibilities of Key Personnel: Directors, Administrators, and Participants. A list of major responsibilities is given for the personnel associated with the project.

Table 3: Qualifications and Responsibilities of Key Personnel: Student Tutors

Background and Qualifications
Advanced students, preferably chemistry majors
Cumulative grade point average (GPA) greater than 3.00
Satisfactory performance in the General Chemistry course
Excellent recommendations from their chemistry professors

Administrative Support
Attend General Chemistry lectures (3 hours per week)
Study the material to be discussed
Attend staff team meetings and feedback sessions (1 hours per week)
Attend initial workshop
Serve as a liaison between faculty and students

Some Responsibilities for the Academic Component (Tutoring)
Serve as models for academic development
Offer tutoring sessions (at least 3 hours per week)
Review course concepts (offer different perspectives
Clarify concepts and answer questions
Help develop problem-solving skills
Use a variety of teaching strategies (cooperative learning, peer-to-peer problem solving, small group techniques such as active participation and face-to-face contact)
Prepare and administer practice tests
Prepare supplementary materials such as modules and assignments

Some Responsibilities for the Personal Development Component (Mentoring)
Form the "learning community"
Serve as models for personal development
Communicate, hear, and share
Develop positive attitudes in participants
Provide support and instill self-confidence
Serve as resources for time management and study techniques

Table 3: Qualifications and Responsibilities of Student Mentors and Tutors. A list of qualifications and major responsibilities (administrative and as tutors and mentors) is given for the student tutors associated with the project.

Collection of Data:
The effectiveness of the Chem-2-Chem Program was assessed using information obtained from various sources. An important source of information for this study was a report compiled by the Planning Office of Cayey University College containing the registered students for each semester organized by academic program and student number. This report contains academic information for each student including university entrance parameters, accumulated grade point average, and number of credits completed. Other information used included official class lists of all General Chemistry course sections with the final grade for each student as well as lists of student attendance for the Chem-2-Chem support groups. Analysis of the data was carried out to identify differences between the data sets obtained during the four semesters of the Chem-2-Chem Program.

A questionnaire was developed for students enrolled in the Chem-2-Chem Program, to ascertain student perception of their study habits, the difficulties they have encountered, and the Chem-2-Chem Program. This questionnaire consists of several sections requesting information regarding general student data and study habits. Additional questions are included regarding student perception about difficulties encountered, usefulness of study materials, and their opinion about the Chem-2-Chem Program experiences. The tutored students rated the tutors capabilities, interest, and explanations as excellent, regular, or deficient. The students also indicated an interest in future participation in the Chem-2-Chem Program.

Results

Student Participation in Chem-2-Chem Program Increases Percentage Satisfactory or Better Achievement in the General Chemistry Courses
The assessment of the Chem-2-Chem Program using official class lists of all course sections with the final grade for each student as well as lists of student attendance for the support groups demonstrated positive results. In general, Chem-2-Chem participants achieved improved exam grades and positive course outcomes (satisfactory or better final grades).

Figure 2 shows the relationship between partial and final exam scores in the General Chemistry I course offered during the Fall semester of 1998 among participants in Chem-2-Chem Program and non participants. An increase is observed in the average partial and final exam scores in the General Chemistry I course obtained by participants as compared with non-participants.

Table 4 shows the relationship between final grade in the General Chemistry course and participation in the Chem-2-Chem Program during four semesters (illustrated in Figure 3). An increase is observed in the percentage of satisfactory or better grades in the General Chemistry course obtained by participants as compared with non-participants. A decrease is observed in the percentage of failing grades obtained in the General Chemistry course by participants as compared with non-participants. In the first semester after implementing the Chem-2-Chem project, a study found that participants with a GPA below minimum satisfactory progress (greater than 2.00) was reduced when compared with non-participants (data not shown).

Figure 2: Comparison of Student Exam Grades (Fall Semester, 1998). Relationship between Partial and Final Exam Scores in General Chemistry I Course and Participation in Chem-2-Chem Program

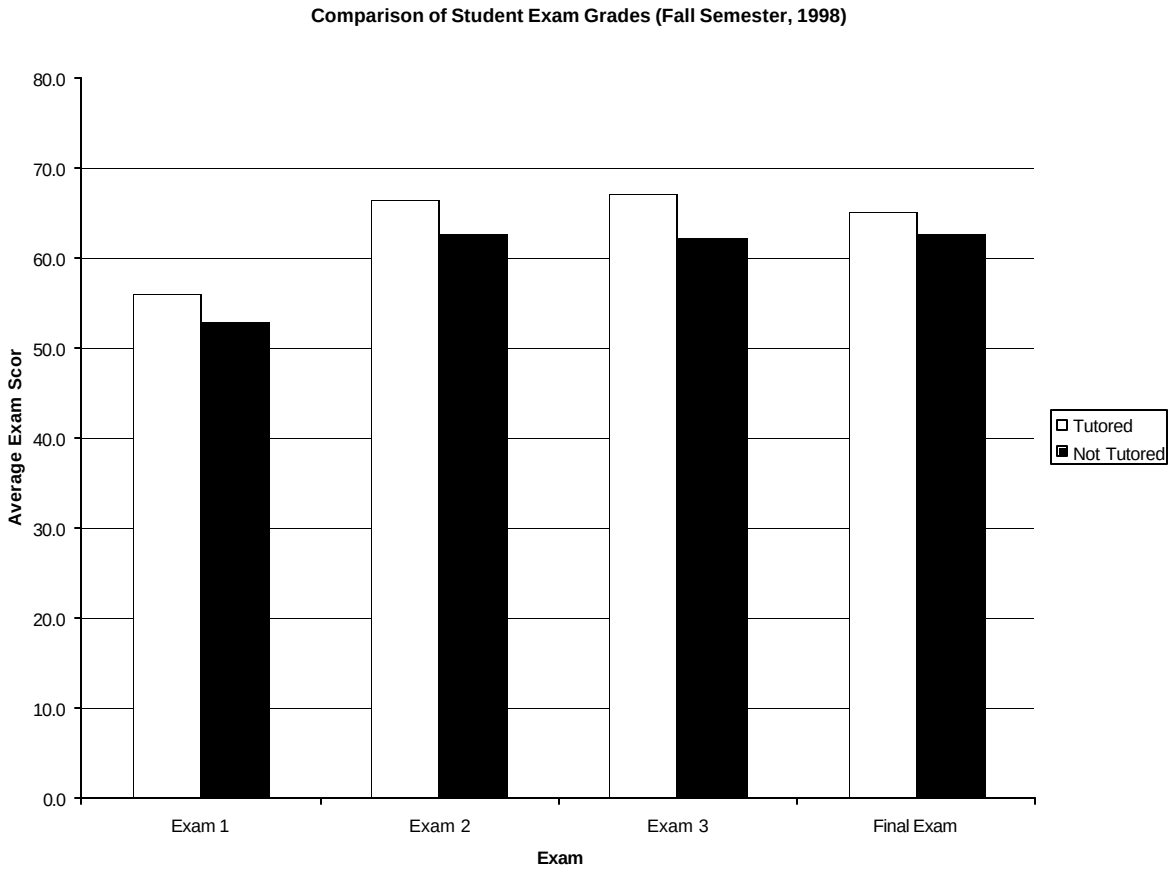

Figure 2: Comparison of Student Exam Grades (Fall Semester, 1998). Relationship between Partial and Final Exam Scores in General Chemistry I Course and Participation in Chem-2-Chem Program. The average partial and final exam scores in the General Chemistry I course obtained by Chem-2-Chem participants were compared with the scores obtained by non-participants. Participation in the Chem-2-Chem Program is defined as attendance in at least 50% of the sponsored activities. Information used in this analysis was obtained from official class lists of all General Chemistry course sections with the exam grades for each student as well as lists of student attendance for the Chem-2-Chem support groups for the Fall semester, 1998. An increase is observed in the average partial and final exam scores in the General Chemistry I course obtained by participants as compared with non-participants.

Table 4: Student Outcomes in General Chemistry Courses During Two Academic Years: Comparison of Tutored (T) and NonTutored (NT) Students

Grades	Fall 1997 CHEM 3131	Spring 1998 CHEM 3132	Fall 1998 CHEM 3131	Spring 1999 CHEM 3132

	T	NT	T	NT	T	NT	T	NT
A	9.8%	8.0%	13.0%	5.0%	22.0%	4.0%	4.3%	6.2%
B	11.8%	11.5%	13.0%	14.0%	14.0%	10.0%	10.6%	10.0%
C	49.0%	28.4%	48.0%	41.0%	37.0%	35.0%	29.8%	22.3%
A+B+C	70.6%	47.9%	74.0%	60.0%	73.0%	49.0%	44.7%	38.5%
D	21.6%	9.8%	17.0%	19.0%	7.0%	14.0%	31.9%	16.2%
F	ND	ND	9.0%	11.0%	8.0%	15.0%	10.6%	20.8%
W	ND	ND	0.0%	10.0%	12.0%	26.0%	12.8%	24.6%
F+W	7.8%	42.2%	9.0%	21.0%	20.0%	41.0%	23.4%	45.4%

T = Tutored Students; NT = Non Tutored Students
ND = Not Determined

Figure 3: Distribution of Final Grades (Average of Four Semesters). Relationship between Final Grade in General Chemistry Course and Participation in Chem-2-Chem Program

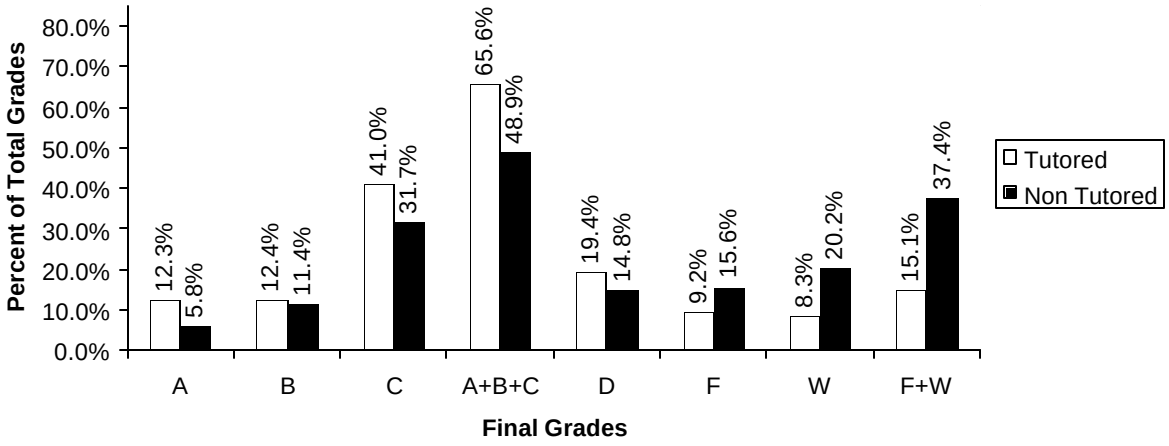

Figure 3: Distribution of Final Grades (Average of Four Semesters). Relationship between Final Grade in General Chemistry Course and Participation in Chem-2-Chem Program. The percentage of final grades in the General Chemistry course obtained by Chem-2-Chem participants were compared with the percentage of final grades obtained by non-participants. Participation in the Chem-2-Chem Program is defined as attendance in at least 50% of the sponsored activities. Information used in this analysis was obtained from official class lists of all General Chemistry course sections with the final grades for each student as well as lists of student attendance for the Chem-2-Chem support groups for the Fall semester, 1998. An increase is observed in the percentage of satisfactory or better (A, B, and C) final grades in the General Chemistry course obtained by participants as compared with non-participants. A decrease is observed in the percentage of unsatisfactory (F) final grades in the General Chemistry course obtained by participants as compared with non-participants. A decrease is also observed in the number of course withdrawals (W) by participants as compared with non-participants.

Results (Continued)

Figure 4 shows the relationship between successful outcomes in the General Chemistry course and participation in Chem-2-Chem Program during four semesters. An increase is observed in the percentage of satisfactory or better (A, B, and C) final grades in the General Chemistry course obtained by participants as compared with non-participants. A decrease is observed in the percentage of unsatisfactory (D and F) final grades in the General Chemistry course obtained by participants as compared with non-participants. A decrease is also observed in the number of course withdrawals (W) by participants as compared with non-participants.

Student Participants Positively Perceive the Chem-2-Chem Program

Responses to a survey given to participants were used to ascertain student perception of tutors and overall perception of the Chem-2-Chem Program. In general, Chem-2-Chem participants perceived the Program with a positive attitude. Figure 5 shows that greater than 95% of the students surveyed rated the tutors as excellent using the included criteria. Greater than 95% of the students surveyed indicated a continued interest in future participation in the Chem-2-Chem Program. Specific comments made by tutored students about the Chem-2-Chem Program are listed in Table 5.

Figure 4: Tutored and Non Tutored Student Success Rate (Average of Four Semesters). Relationship between Percentage Satisfactory or Better Achievement in General Chemistry Courses and Participation in the Chem-2-Chem Program

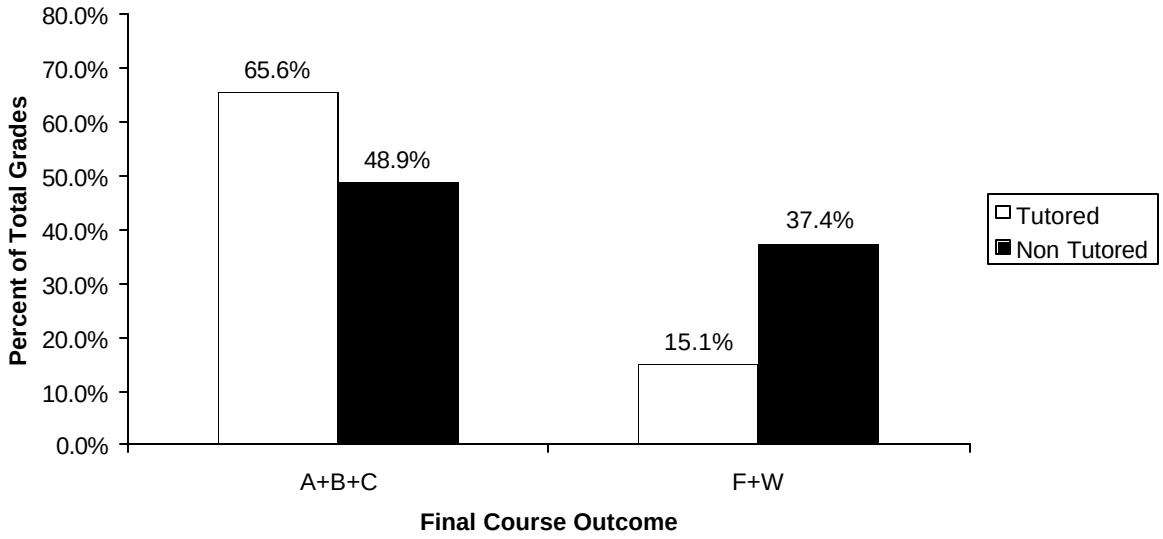

Figure 4: Tutored and Non Tutored Student Success Rate (Average of Four Semesters). Relationship between Percentage Satisfactory or Better Achievement in General Chemistry Courses and Participation in the Chem-2-Chem Program. The percentage of satisfactory or better grades (A, B, and C) and failure grade (F) and course withdrawal (W) in the General Chemistry course obtained by Chem-2-Chem participants were compared with similar grades obtained by non-participants. Participation in the Chem-2-Chem Program is defined as attendance in at least 50% of the

sponsored activities. Information used in this analysis was obtained from official class lists of all General Chemistry course sections with the final grade for each student as well as lists of student attendance for the Chem-2-Chem support groups for four semesters from Fall 1997 to Spring 1999. An increase is observed in the percentage of satisfactory or better grades in the General Chemistry course obtained by participants as compared with non-participants. A decrease is observed in the percentage of unsatisfactory and failing grades obtained in the General Chemistry I course by participants as compared with non-participants. The percentage of participants withdrawing from the course was also reduced when compared with non-participants.

Figure 5: Responses to the Survey of Tutored Students

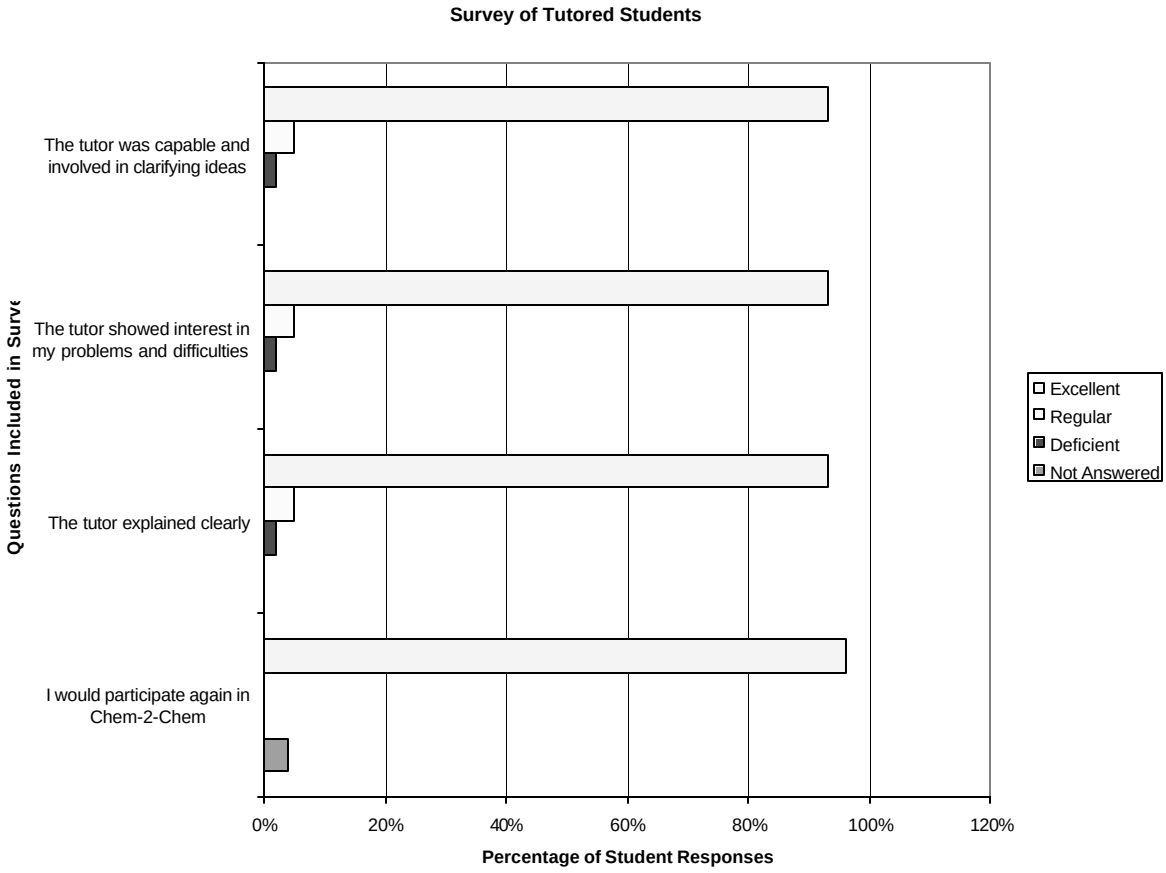

Figure 5: Responses to the Survey of Tutored Students. Students were given a questionnaire to assess the effectiveness of the student tutors and the Chem-2-Chem Program in general. The tutored students rated the tutors capabilities, interest, and explanations as excellent, regular, or deficient. The students also indicated an interest in future participation in the Chem-2-Chem Program. The percentage of student responses for the Fall semester, 1998 was tabulated. Greater than 95% of the students surveyed rated the tutors as excellent using the included criteria. Greater than 95% of the students surveyed indicated a continued interest in future participation in the Chem-2-Chem Program.

Table 5: Tutored Student Comments about Chem-2-Chem

"I learned the value of not quitting."
"I improved the way of understanding chemistry."
"Friendship"
"Greater Success"
"Motivation"
"I learned better the material I could not understand in class."
"I was able to clear up my doubts."
"Help"
"It helped maintain and improve my study habits."

Table 5: Tutored Student Comments about Chem-2-Chem. Comments made by tutored students about the Chem-2-Chem Program.

Discussion

The impact of the Chem-2-Chem Program on tutored student participants has been significant. Tutored students from different departments and programs enrolled in the General Chemistry course increased academic achievement when compared to the total population of enrolled students. The percentage of students obtaining a satisfactory or better final grades in the General Chemistry course was 16% greater among tutored students than among non tutored students. The tutored students improved attitudes, study habits, discipline, organization, interest, and enthusiasm. Communication and teamwork skills help prepare these students for success in the workplace.

The Chem-2-Chem Program also had a significant impact on student tutors. Tutors were able to review basic chemistry concepts needed for professional exams and graduate studies. They gained a deeper understanding of chemistry useful for advanced courses. They developed communication skills and teaching experience. They improved their own study habits. The tutors received payment for an on campus experience.

Assessment of the Chem-2-Chem Program carried out over the last two years has shown dramatic results. On average, tutored students obtained better grades in all of the exams compared to non-tutored students. This improved the success rate for program participants. Over the four semesters included in this study, 12.3% of tutored students received an "A" for the final course grade, compared with only 5.8% of the non-tutored students. The failure and drop rates were also impacted. For the final course grade, 9.2% of tutored students received an "F" compared with 15.6% of the non-tutored students. Only 8.3% of tutored students dropped the course (and received an "W") compared with 20.2% of the non-tutored students. An added benefit was observed in that the Chemistry Department faculty became more approachable to students due to the tutors' teamwork spirit.

Independent pedagogical research at a number of universities is in agreement with the results obtained in the Chem-2-Chem Program. The "Workshop Chemistry Project: Peer-Led Team Learning," a program based on tutoring by advanced chemistry students, similar to the Chem-2-Chem Program in the peer-led learning component, has shown a "statistically significant improvement in grades, retention, and levels of student satisfaction" (Grosser and Roth, 1998).

Individualized "learning communities" that provide a supportive nurturing environment for students

were designed as part of the Chem-2-Chem Program to supplement the General Chemistry courses. This strategy was developed to address the institutional problem regarding student retention. This personalized attention met the academic and emotional needs of our students. This interactive approach reaches out to students and successfully meets their needs with dramatic results. A substantial increase in satisfactory course outcomes and development of positive attitudes by program participants was observed. This strategy can serve as a model for educational excellence and extended to other science courses at this and other institutions.

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