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ABSTRACT

This report examines an attempt to use cooperative learning in two sections of a college chemistry course and focuses specifically on male and female student attitudes and achievement in the course. A total of 46 students participated. One lab section used cooperative structures throughout an entire 16-week semester while the other section used independent lab structures until week 8 at which time cooperative learning was employed. While cooperative learning did not produce differences in achievement along gender lines, there were discernible differences in male and female attitudes toward cooperative learning and in the effects that cooperative learning might have on attitudes and beliefs toward chemistry. Cooperative learning reduced the negative slide on self-perception of ability, interest, and effort among females. Furthermore, the preference for this mode of learning was heightened among females. A major adverse effect was that females expressed a disproportionate feeling that their individual performance might have negative effects on others in such practices as group grading and jig sawing information for student presentation. The survey form is appended. (GLR)

Cooperative Learning in a College Chemistry Course

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Cooperative Learning in a College Chemistry Course

Introduction

Recent reviews have reported on the differing participation patterns of women and men in science study and career choice. Factors contributing to the differences include attitudes which lead women to select themselves away from science courses (Chipman and Thomas, 1987; Oakes, 1990). Furthermore, a number of authors have suggested that there are differences in the way males and females become engaged in learning. Among females there is a greater preference for learning as a socially connected activity (Belenky, Clinchy, Goldberger and Tarule, 1986). Cooperative learning provides one way of organizing learning in a more socially connected manner (Johnson and Johnson, 1987) .

This pilot study reports on an experiment to use cooperative learning in two sections of a college chemistry course and focuses specifically on male and female student attitudes and achievement in the course. In total there were 46 students involved, evenly divided between males and females. In the study, one lab section used cooperative structures throughout an entire 16-week semester while the other section used independent lab structures until week 8 and then switched to cooperative learning. The report focuses on attitudinal and achievement outcomes and on the processes of laboratory experiences as observed by the researchers and reported by the various participants. In this design, attitudinal data was gathered primarily through a pre and post survey at the beginning of the semester and then again at the end. Other data sources reviewed include observations of labs, student and teacher journal entries and reflections, and interviews. Student examination scores were used to assess achievement. The primary interest is in ascertaining the potential differential impact of cooperative learning when examined along gender lines. The report will explore the significance of cooperative learning as a mitigating factor in attitudes and achievement about chemistry among college females and males.

Attitudes

A survey was devised to assess student attitudes concerning preferences about working with others or working alone, and about the study of chemistry and the study and practice of science. Items were clustered around the following categories: desirability and effectiveness of working together and alone, self perception of capability in chemistry, effort put forth, and interest in chemistry. Comparisons were made between the responses made at the beginning of the course and at the end of the course for all students and for male and female students. The comparison of survey responses is limited to those students who responded to both rounds of the survey (n=39). Students who responded to only one round were pulled from the set. While this reduced the population size, it has the advantage of keeping the population constant.

Working Together and Alone

Attitudes about working together and alone were measured along two dimensions: preference and effectiveness. At the beginning of the semester, 23% of the respondents agreed or strongly agreed that they preferred to work alone on lab projects, and 18% indicated low or very low liking for working with others. At the end of the semester, 26% indicated that they preferred to work alone. Thus, after having experience with working in a lab situation in a cooperative mode, a higher proportion of students indicated a preference for working alone rather than in a group.

An examination of responses along gender line, however, shows noteworthy gender differences. At the start of the semester 30% of the males indicated strong or very strong agreement that they preferred to work alone on lab projects. At the end of the semester 40% gave that response. In contrast, female respondents began the semester showing less preference than males for working alone (16%, 5% strongly agree, 11% agree) and moved more strongly to that position at the end. Only 11% indicated agreement (none strongly agreed), and the percentage of disagreement went up from 42% to 53%.

		Male		Female	
		S. Agree	Agree	S. Agree	Agree
I prefer to work alone on lab projects.					
	Pre	5%	25%	5%	11%
	Post	0%	40%	0%	11%

Efficiency was the second dimension examined. This was measured by responses to questions about whether working with others was helpful or distracting in learning chemistry, and self perception about whether the respondent learned better working alone or with others. Little difference is noted in the perceived benefit in working with others in the learning of chemistry. At the outset, 97% agreed or strongly agreed that it was helpful; at the end 95% responded that way. Responses were comparably high for males and females. At the outset of the semester, 16% of the students found working with others in lab to be distracting and confusing, but at the end only 10% responded that way. However, males were more likely to agree or strongly agree that it was distracting (20%) than females (10%). For females, that agreement went to zero at the end, while for males it remained at 20%. However, the percent of students responding with strongly agree declined by 10% for males, indicating the same directional shift.

		Male		Female	
		S. Agree	Agree	S. Agree	Agree
I find working with others in labs distracting and confusing.	Pre	10%	10%	5%	5%
	Post	0%	20%	0%	0%

On the dimension of self perception about whether the respondent learned better working with others, there was a slight increase in the percentage who agreed or strongly agreed that they learned better if they worked with others (from 64% to 69%). All of that increase, however, came from the female respondents (from 68% to 79%), while male responses stayed at the same level of overall agreement (60%). However the strongly agree response declined for both males and females.

		Male		Female	
		S. Agree	Agree	S. Agree	Agree
In general, I learn better if I work with others.	Pre	25%	35%	26%	42%
	Post	10%	50%	21%	58%

Overall, there were a total of ten questions on the survey (See Appendix A) that focused on student perceptions of working alone or working together in Chemistry.

Student responses were examined for significant differences between male and female responses before and after treatment (employment of cooperative learning structures). A significant difference (p=.0481) was revealed between male and female responses on the pre-survey. Additionally, a significant different (p=.0441) was revealed for these same groups at the post survey time. In sum, neither males nor females significantly shifted their feelings regarding working together or alone in college chemistry through the activities in this pilot study.

Self Perception of Capability

Items in this category attempted to ascertain how students perceived their capability in chemistry. As a whole, there was no change at the end of the course in comparison to their perceptions at the beginning. At the outset, 85% of all students indicated that their capability in chemistry was high or very high. At the end of the course 87% gave that response. There were, however, noteworthy differences along gender line. The male responses of very high or high increased from 85% to 100%. In contrast, the female response declined from 84% to 74%. Similarly, at both the outset and conclusion of the course 95% of the male students indicated that they had a good grasp of chemistry, whereas 95% of the females indicated that attitude at the beginning, but 84% gave that response at the end.

		Male		Female	
		Very High	High	Very High	High
Capability in chemistry.					
	Pre	15%	70%	21%	63%
	Post	25%	75%	11%	63%

		S. Agree	Agree	S. Agree	Agree
I have a good grasp of chemistry.					
	Pre	35%	60%	11%	84%
	Post	40%	55%	16%	68%

		S. Agree	Agree	S. Agree	Agree
Chemistry is very difficult for me to understand.					
	Pre	0%	15%	11%	26%
	Post	5%	0%	5%	42%

Additionally, no significant differences were revealed between means of student responses on the pre and post survey for males and females for the six items on the survey that focused on student self-perception of capability in chemistry.

Effort

Little change occurred in student perception of effort expended in the study of chemistry. At the outset 90% responded that they agreed or strongly agreed that they put considerable effort into the study of chemistry. At the end of the semester, 87% responded that way. Again, however, there was a difference in gender response. Male responses of agree or strongly agree increased from 80% to 85% whereas female responses declined from 100% to 89%.

		Male		Female	
		S. Agree	Agree	S. Agree	Agree
I put considerable effort into the study of chemistry.					
	Pre	10%	70%	32%	68%
	Post	15%	70%	42%	47%

Interest

The survey responses as a whole indicate little change in student interest in chemistry and science in general. At the beginning of the course 90% of the students indicated an interest in pursuing further study in chemistry; at the end 92% expressed that interest. Gender comparisons show higher (95%) interest on the part of males than females (85%) at the beginning and a shift upward for males (100%) at the end of the semester and no noteworthy change for female respondents (84%). However, a closer examination of female responses indicates a shift in degree of agreement as the proportion of strongly agree moved from 32% to 42% over the semester, and a

decline from 16% to 5% for those who disagreed. Similarly, among females, there was a positive shift in expressed interest in pursuing a career in chemistry. The percentage strongly agreeing went from 16 to 21, the proportion of agree stayed the same, and the percentage of strongly disagree declined from 11 to 5. Thus all of the shift was in a positive direction toward consideration of a career in chemistry. In contrast, among males, there tended to be a bipolar shift with some moving to a position of stronger agreement while others shifted in the opposite direction toward showing less interest in pursuing a career in chemistry.

		Male		Female	
		S. Agree	Agree	S. Agree	Agree
I am interested in pursuing further study in chemistry.					
	Pre	55%	40%	32%	53%
	Post	50%	50%	42%	42%

		Male		Female	
		S. Agree	Agree	S. Agree	Agree
I am interested in pursuing a career in chemistry.					
	Pre	45%	40%	16%	47%
	Post	50%	30%	21%	47%

In addition to the surveys, informal interviews were held with students during the last week of classes to gather additional insight into student responses to their experiences in chemistry. Students were chosen at random as they performed final experiments or cleaned laboratory shelves, drawers and equipment. Each student or groups of students was approached with a similar question, "Do you like working with others?", and the interviews developed in response to student comments. In total, the interviewers spoke with six females and four males, and only one of these ten students responded that she didn't like working with someone else in the laboratory. Interestingly enough, this student was a female and she responded that she grew up on a farm with no brothers and sisters and still liked this kind of independence.

Some of the students interviewed indicated that working together in science classes was not a new phenomenon for them. Some indicated that they had worked in small groups in other classes at this university (e.g., biology) and in high school.

The final lab experiment gave students the options to choose an experiment of their own design and they could choose to work with whomever they chose. The interviewer asked several small groups why they chose to work with whom they did. Responses indicated that perceived knowledge of science was the predominant reason for choosing one student to work with one over another. Specifically, gender was not at issue. For example, one woman who thought she would get an A in the class chose to perform a final experiment that was "Basically pretty easy and very much like one we'd done before in class." She told the interviewer that she preferred to work with someone else, but in this experiment "it didn't matter." She told the interviewer that she understands the material better in this course than in a previous chemistry course, but couldn't tell the interviewer why. When asked if she thought that women liked to worked better in pairs and men liked to work alone she responded, "It might seem that way in this class. Never thought of it until you just asked. No." When asked whom they would pick to work with out of all the peers in the room one responded, "Tom." When asked why, she responded, "He's had a lot of science and experience."

Therefore, it seemed to the interviewer at the time the interview notes were taken and later in reflecting upon them that students preferred to work with others, and if they were given a choice as to which student or students they could choose from, perceived knowledge was the primary consideration. However, when examining gender issues it appears that females may choose to work together for different reasons than do males. For example, one female sought the interviewer out to tell her, "I think men are more critical than women, but I'm not sure it's true. If you make a mistake you can work it through with a woman." This particular female has aspirations to be a biologist and she expressed the feeling that the males in her particular lab section had more science than the women had. The course instructor confirmed that this group did indeed have more males with good science and math backgrounds and that the disparity was more pronounced this semester than it had been in the past.

The instructor provided another noteworthy observation about his perception of students working together .

> I think the females like to work together and with some of the males. The males tend toward working independent-cooperatively but accept cooperative structure O.K. When it comes to combining grades the males are apt to worry about others pulling their grade down where the

females are concerned about pulling others' grades down. In the jigsaw the females felt more pressure than the males because of this.

This observation was confirmed by evidence from the student journals. A reading of a sampling of the journals indicated a higher level of concern on the part of the females for the effectiveness of their presentations in a jigsaw activity and for the impact it would have on others. There was also greater concern about the impact on others of their performance on the test where group member scores were averaged.

In summary, data from observations, interviews and journal entries confirms and elaborates some of what emerged from the surveys. What is most significant are the additional insights provided as to the reasoning behind the selection of partners and the differences in concerns and reservations about cooperative learning.

ACHIEVEMENT OUTCOMES

Student achievement was evaluated by comparing student performance on exams in each of two lab sections. All students were given the same four examinations regardless of section, two exams before the midterm mark and two exams after the midterm mark. For purposes of this evaluation the first two exam scores were added to comprise a midterm accumulation of points on exams testing achievement, and the last two exam scores were added to form a comparison total for the second half of the semester.

No significant difference was revealed between exam scores for group A (independent then cooperative) and group B (cooperative) for either gender at the midpoint of the study. At the midpoint the independent group was exposed to the same cooperative structures in laboratories that the cooperative group was being exposed to. At the end of the semester a significant difference of $p<.05$ ($p=.0159$) was revealed for exam scores between the different treatment groups.

When t-tests were performed to compare exam scores for group A's (independent then cooperative) midpoint achievement totals a significant difference ($p=.0004$) was revealed. A significant difference ($p=.0132$) was also found for comparison of exam scores for group B)cooperative) at the midpoint and at the end of the semester. Apparently, both groups of students benefited from cooperative learning structures in chemistry lab.

Finally, t-tests were also performed on exam scores of males and females in the he different treatment groups. None were found. Cooperative learning structures appeared to not make a difference for females' achievement. However, one must keep

in mind that the course exams were primarily assessing overall learning of which cooperative learning laboratory structures were only a part.

PROCESSES

The researchers also observed four labs during the semester: two prior to the midterm and two after the midterm. These observations provided insight into the processes of interaction and communications during the lab sessions.

In the cooperative group, we observed students working with and communicating with each other throughout the lab session. While the groupings appeared to be more gender based than not, there was considerable communication across gender lines. The talk and work was oriented to the tasks on hand with very little extraneous social talk observed. During the instructor's presentation on the spectrometer, we observed females tending to be more likely to take notes and to move in closer during the explanations than did the males.

At the end of the course, students in both groups appeared to have learned to work effectively and efficiently together and seemed to enjoy it. Interactions occurred among a broad array of students and there appeared to be an absence of cliquishness. We observed both males and females asking questions and seeking answers across gender lines. The overall atmosphere of the lab appeared to be a comfortable environment for communication. Students appeared to be positive about working together, and only one of the ten students interviewed at the end of semester indicated that she preferred to work alone.

The instructor remained enthusiastic about cooperative learning throughout the semester. This enthusiasm can be seen in his field notes. In particular he liked the increased communication skills and confidence that he saw as developing as a direct result of cooperative learning practices.

SUMMARY AND CONCLUSIONS

While cooperative learning did not produce differences in achievement along gender lines, there are discernible differences in male and female attitudes toward cooperative learning and in the effects that cooperative learning might have on attitudes and beliefs toward chemistry. In this pilot study, it appears that cooperative learning had a positive effect on reducing the negative slide on self perception of ability, interest, and effort among females in this chemistry course. Furthermore, with experience with cooperative learning and working together in chemistry lab, the

preference for this mode of learning was heightened among females. This responsiveness to females' preferred social organization of instruction did not, however, appear to have negative consequences for males in the class. The one major adverse effect that is worth noting is the feeling expressed disproportionately by females that they are concerned about how their individual performance might have negative effects on others in such practices as group grading and jig sawing information for student presentation. This dimension (which might be called the albatross effect) has been examined with learning disabled children in elementary grades and is worth more full and careful examination in future studies of cooperative learning in college chemistry and other science courses.

Finally, a review of the data suggests several dimensions that should be explored more fully in subsequent studies. Several key factors that deserve attention include the selection of partners, the reasons for preferring cooperative learning, and factors that might influence those preferences.

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APPENDIX A

PLEASE PROVIDE THE FOLLOWING INFORMATION:

NAME_____ Also put your name in the "Instructor" box on the General Purpose Answer Sheet (Scan Sheet). Responses to surveys will be confidential and anonymous. A Survey Code number will be assigned to each survey response form and names will be removed from the forms before processing.

SURVEY CODE #___

Major_____ Minor_____

Year in school(Fr. Soph. Jr. Sr. Other)_____ Sex(M/F)_____

USE THE "UW-EC GENERAL PURPOSE ANSWER SHEET" (SCAN SHEET) TO RESPOND.

Considering experiences you have had, respond to each statement using the following scale:

A Strongly Agree
B Agree
C Disagree
D Strongly Disagree

1. Science is best done working alone.
2. Chemistry is very difficult for me to understand.
3. Lab work is helpful in learning key concepts and processes in chemistry.
4. I prefer to work alone on lab projects.
5. Working with others helps in learning chemistry.
6. Preparing lab reports is best done working alone.
7. I effectively communicate my understanding of chemistry.
8. Explaining concepts in chemistry to others helps me better understand the concepts.
9. In the real world, scientists do most of their important work working alone.
10. I see myself as a competent student of chemistry.
11. I see myself as a competent student of science.
12. I think I have generally a good grasp of chemistry up to this point in my studies.
13. I find working with others in labs distracting and confusing.
14. In general, I learn better if I work alone.

15. In general, I learn better if I work with others.

16. Other students in my classes are generally helpful.

17. Other students in my classes are generally too competitive.

18. I put considerable effort into the study of chemistry.

19. I am interested in pursuing further study in chemistry.

20. I am interested in pursuing a career in chemistry.

Using the scale which follows, how would you rate yourself on each of the items below.

A Very High
B High
C Low
D Very Low

21. Interest in science

22. Interest in chemistry

23. Liking to work with others

24. Ability to communicate scientific ideas

25. Effort in learning chemistry

26. Capability in science

27. Capability in chemistry

Overall, how would you describe your ability in chemistry?

Overall, how would you describe your attitude toward the study of chemistry.