Using Cooperative Learning in Clinical Laboratory Science Education

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OBJECTIVE: To compare performance of students instructed by cooperative learning (CL) activities with those taught by lecture. A secondary objective was to assess students' perceptions about their ability to work in teams before and after their exposure to these instructional approaches.

DESIGN/SETTING/PARTICIPANTS: CL was incorporated into the immunology/serology course of a university-based clinical laboratory science (CLS) program. Twenty-two students participated in a 4-week study and were randomly assigned to one of two study groups.

INTERVENTION: One group received the course material by CL activities, and the other group was exposed to the material through lecture.

MAIN OUTCOMES MEASURE: Mean examination scores for CL and lecture groups were compared using an independent samples t-test. Teamwork knowledge, skills, and attitude (KSA) assessment rated students' perceptions of their ability to work in a team environment pre and post tests were compared using a 2x2 repeated measures ANOVA.

RESULTS: No significant difference was found between mean examination scores of students who acquired their knowledge by CL activities (85.09%) and those taught by lecture (82.18%). Teamwork KSA means scores pre and post tests (22.5, 22.6 CL; 22.7, 21.6 lecture) were not significantly different.

CONCLUSION: Results suggest that the incorporation of CL activities did not reduce the students' academic performance or self-perceptions of their ability to work in teams. The use of CL in the classroom, student laboratory, or clinical setting may help prepare students for the role they will be expected to perform as laboratory professionals.

ABBREVIATIONS: CL = cooperative learning; CLS = clinical laboratory science; KSA = knowledge, skills, and attitude.

INDEX TERMS: active learning; cooperative learning; instructional methods; teaching strategies.

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In higher education, instructors frequently use lecture as an instructional approach to transmit information to students. The use of a predominantly lecture-based approach assumes that if one has content expertise, one can transfer knowledge most efficiently through its use. Considering the variety of learning styles that students possess, traditional lecture is not always the most effective way to transmit information. Furthermore, the lecture-based approach alone will not prepare students for complex demands found in the workplace such as the ability to think critically, collaborate with others, and engage in active problem solving. The goal is to find and implement instructional methods that will better address differences in student learning styles and improve the student's ability to think critically, use higher-level reasoning, and recognize the responsibility of becoming a life-long learner.[1]

The Reports and Reviews Section seeks to publish information on important clinical laboratory-related topics such as technological, clinical, and experimental advances and innovations. Case studies and literature reviews are also included. In addition, brief reviews of books, computer programs, audiovisual materials or other materials of interest to readers are appropriate for this section. Manuscripts and literature reviews published as a Report are peer reviewed. Direct all inquiries to Isaac Montoya PhD, Affiliated Systems Corporation, 3104 Edloe, Suite 330, Houston TX 77027-6022. (713)439-0210, (713)439-1924 (fax). imontoya@affiliatedsystems.com

Cooperative learning (CL) is an instructional method in which small groups of learners work together to maximize their own and each others' learning.[1] The use of CL in the classroom has been shown to promote student achievement and self-esteem, develop higher level cognitive skills, and increase levels of comprehension, problem solving, and communication skills.[2] The student becomes an active participant in the classroom, working as a team member with certain responsibilities that are shared with the group. CL provides students with face to face help and support, opportunity for leadership, practice in conflict resolution, and experience in the process of improving group effectiveness.[1-3] Literature suggests that the use of interactive teaching methods, such as CL, helps students to pay attention and renew interest while in class.[3]

Few studies have evaluated the use of CL in allied health education. One study evaluated CL in an interdisciplinary allied health course. Ninety-three students, 20 of whom were medical technology majors, participated in eight instructional units. Participants were assigned to twelve numbered groups with seven to eight students per group. Eight quizzes were administered, four in group consensus mode and four individually. Results revealed that students taking quizzes as a group scored higher than those who took them individually on seven of the eight quizzes. However, differences between groups were statistically significant (p <0.05) on only four quizzes. In addition, all subjects took a 50 item multiple choice final examination based on the course objectives. Scores on the examination were divided into units and recombined for the two treatment groups. Between groups there was no statistically significant difference between final examination scores for students who took the unit quizzes as a group and those who took them individually.

Students were asked to rate their perceptions in regard to clarity, understanding, and utility of topics studied in this course. Topics studied included group development, problem solving, communication, ethics, handicaps, patient problems, legal problems, aging, and death. A statistically significant difference in students' perceptions related to taking quizzes in a group or individually was noted on six of the eight quizzes. The investigator concluded that CL resulted in greater understanding and more positive attitudes regarding the allied health topics studied. A majority of students preferred group consensus examinations to the traditional individualistic mode. Students felt the experience had a positive influence on their attitudes and improved their ability to learn the content.[4]

In a second study, CL was evaluated in a medical technology program for a period of nine years. One hundred and forty-three students were separated into three cluster sets: solo, group, and mix. The solo set took all exams individually. The group set took all exams in a group. The mix set took exams in two parts, individually and in a group. All sets took two exams and a final examination in a laboratory instrumentation course. Results on the first examination showed that there was a statistically significant difference (p <0.05) between scores of solo and mix sets and scores of group and mix sets, but no difference when scores of solo and group sets were compared. Evaluation of the second examination revealed a statistically significant difference (p <0.05) in the scores of solo and group sets and the scores of solo and mix sets, but no difference in scores between group and mix sets. Results on the final examination showed no differences in any of the set comparisons.

The authors hypothesized that if CL increased student achievement on exams, one would expect the students in a group or in the mixed cluster set to perform significantly better on exams than those taking exams individually. The results did not support this expectation, however the study did show that CL increased student's scores on some exams. It was concluded that perhaps student scores on the final examination do not truly represent what they had learned regardless of the instructional technique. The amount of material presented during this term may be overwhelming to students and prevent them from adequately preparing for the final examination. These authors offered anecdotal support that CL had a positive effect on students' ability to work in groups; they are confident that CL is an effective learning strategy and will continue its use.[5-8]

The decade of the 1980s saw business and industry moving toward greater cooperation and involvement of workers with management in planning and decision making.[2] The concepts of collaboration and teamwork are fundamental in the medical sciences, specifically in the clinical laboratory. Partnerships between laboratory specialties and other healthcare professionals will often enhance patient diagnosis and, ultimately, patient treatment and care. The use of CL can lay a foundation of teamwork and participation for students that should ease their transition from the role of student to the complex landscape of the workplace. The major advantage of CL is the ability to expose students to an instruction in a medium that parallels the real world.

The social interdependence theory is the basis of CL and was used as the model for this study.[9] It provides educators

with a conceptual framework for understanding how CL can be structured, adapted, and applied to a wide variety of instructional situations. CL activities are best used when tasks require conceptualization and problem solving, higher level reasoning, and critical thinking. Simply placing students in small groups produces some benefit, but incorporating CL techniques produces higher levels of learning.[10-17]

The purpose of this study was to evaluate the use of CL in the CLS classroom. CL was compared to traditional lecture in an immunology/serology course. Differences in student's performance on an examination were evaluated between those taught by traditional lecture versus CL. Team performance ratings before and after instruction and differences in course and instructor evaluations were also compared between the two groups.

METHODS

Twenty-two CLS students enrolled in an accredited, university-based Bachelor of Science program participated in this study. After a thorough explanation of the nature of the study, students were provided informed consent forms and asked to volunteer. All twenty-two students consented and demographic data were gathered. Students who agreed to participate were stratified according to their grade performance in a prerequisite immunology course and then randomly assigned to either the CL (n = 11) or lecture (n = 11) group. During the 4-week study period, the intervention group participated in CL activities facilitated by one research investigator while the comparison group attended lectures given by the course instructor. The study was based on a quasi-experimental design.

At the beginning of each two hour CL session, the selected CL activity was explained. The research investigator provided direction for the CL activity, monitored group participation, and answered questions. The types of CL activities used were ABC, jigsaw, roundtable, structured problem solving, and think pair share as described by Hughs and Townley and Nolinske and Millis (see appendix).[2,18]

Data were collected during a 4-week period completed in September 2000. Intervention and comparison groups were evaluated for knowledge of immunology/serology course content using a 100 point multiple choice and matching item examination that had been given to previous classes. Using data from students' (n = 67) past performances, internal consistency reliability coefficients were evaluated using the Test Scoring and Analysis Program (TSAP).[19] Content validity was determined for this examination to ensure that test items satisfied serology content domain. A panel of experts reviewed the examination and evaluated items for representation of each level of Bloom's taxonomy for the cognitive domain, including knowledge, comprehension, application, analysis, synthesis, and evaluation.[20]

Subjects in both groups completed the Teamwork-KSA[21] Assessment pre and post intervention. This tool evaluates essential knowledge, skills, and abilities of individuals to work effectively in teams. In addition to yielding an overall score, the Teamwork-KSA measures two main categories: interpersonal skills and self-management. Interpersonal skills include conflict resolution, collaborative problem solving, and interpersonal communicative skills. Self-management skills reflect goal setting and task coordination.[21]

At the completion of the 4-week period, the course examination was given to both groups and the Teamwork-KSA assessment was administered. Examination score data were collected and analyzed using independent samples t-test and Teamwork-KSA results were evaluated using a 2x2 repeated measures ANOVA. In addition to tests of statistical significance, effect sizes measured by partial-eta squared and Cohen's *d* were calculated. These were used to determine if study results were clinically significant or noteworthy, whether or not they were statistically significant.[22]

The course grade consisted of a knowledge examination, laboratory examination with technical proficiency section, case presentation, journal review (lecture section only), CL activities (CL group only), and final examination. Participation in CL activities comprised 5% of the final grade for students in the CL group. This provided incentive for active participation in group activities. The students were given individual and group scores equally weighted for this portion of the course grade. A journal review component comprised the corresponding portion of the course grade for the students in the lecture section. The study compared scores on the first examination (15% of course grade) of the three course examinations.

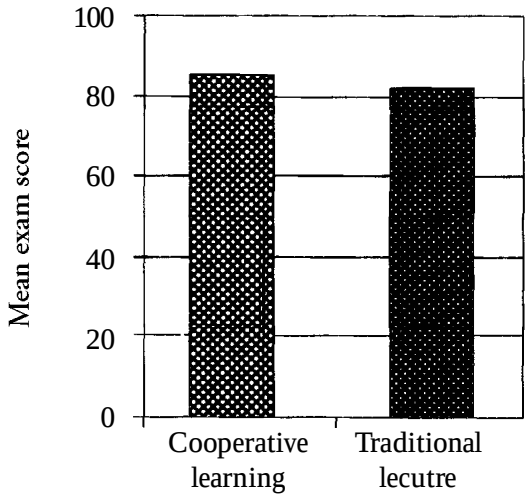
RESULTS

The majority of the students in both groups were non-degreed, not employed outside of school, and of traditional college age (mean for both groups = 22 years). Most students were not married (CL = 90.9%, lecture = 72.7%) and both groups consisted of 90.9% females. The two primary ethnic groups represented in this study were African American (CL and lecture = 27.3%) and European American (CL

= 72.7%, lecture = 45.5%). More than half of the participants in both groups had not experienced CL teaching methods in any previous college course.

An independent samples t-test was performed to compare the mean examination results of the subjects participating in CL with those attending lectures. Mean examination scores for CL and lecture groups were 85.09% and 82.18% respectively (Figure 1). The difference between the means of the two groups was not statistically significant or noteworthy (t = 0.814, p = 0.425; Cohen's d = 0.35). Teamwork KSA mean scores within and between groups for pre and post tests showed no statistically significant differences (see Tables 1 and 2, Figure 2). Effect size measurement revealed somewhat noteworthy differences between groups in only two subcategories, collaborative problem-solving and goal setting, and performance management (partial eta^2 = 0.094 and 0.147 respectively) (Table 2).

Figure 1. Comparison of teaching methods



t = 0.814 p = 0.425 Cohen's d = 0.35

At the completion of the course, the students rated the instructors and course overall. Evaluation scores were based on a 1 to 5 rating scale (5 = excellent, 1 = poor). Students in the traditional lecture group rated agreement between the objectives and examination higher than the CL group (lecture mean = 4.52, CL mean = 4.10). Evaluation scores for organization and clarity of presentation also favored the lecture group (lecture mean = 4.37, CL mean = 3.70). Overall mean course evaluation scores for the two groups differed (lecture mean = 4.36, CL mean = 3.50) though several student comments from the CL group were positive. Students remarked that CL forced them to prepare earlier for the examination by continuous association with the content through CL activities. They liked having a more active role in their learning, and concepts were more clear because of the research required when instructing and working with other students.

Table 1. Teamwork-KSA scores by groups

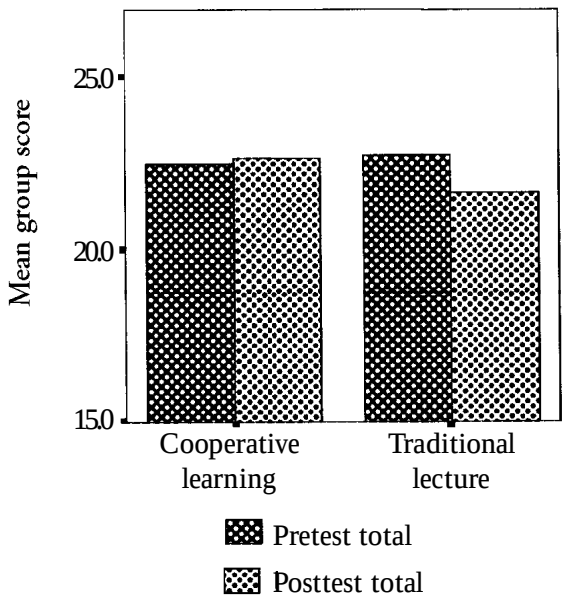
	Cooperative learning				Traditional lecture			
	Pretest		Post test		Pretest		Post test	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Teamwork-KSA Total	22.5	4.3	22.6	4.0	22.7	3.5	21.6	3.0
Interpersonal Skills Subtotal	15.0	3.1	15.2	3.3	15.4	2.7	15.1	2.5
Conflict Resolution	2.9	0.8	2.9	0.9	2.7	0.8	3.1	0.3
Collaborative Problem-Solving	4.5	1.8	4.7	1.7	5.2	0.9	4.5	1.7
Communication	7.5	1.4	7.5	1.7	7.4	2.0	7.5	1.6
Self-Management Subtotal	7.5	1.8	7.5	1.3	7.4	1.6	6.5	1.2
Goal Setting and Performance Management	3.5	1.2	3.9	0.9	3.7	1.3	3.5	1.3
Planning and Task Coordination	4.0	1.1	3.5	1.2	3.6	1.0	3.1	1.3

Note: Ranges for Total Teamwork-KSA score 0-35 (M = 22.41; SD = 5.27); Interpersonal Skills 0-23 (M = 14.576; SD = 3.813); Self-Management 0-10 (M = 7.540; SD = 1 .913). These norms are based on the scores of 388 Teamwork-KSA tests collected.

DISCUSSION

CL is based on multiple human interactions, is more proactive than lecture, and offers greater promise to stimulate a wider range of students in reaching their full scholastic potential.[1,23,24] Although examination scores were nearly the same for both groups indicating that CL did not increase knowledge acquisition or negatively affect learning outcomes, it remains a worthwhile supplementary teaching approach if it improves interpersonal relationships, self-esteem, communication skills, and collaboration among classmates.[5,14-16]

Figure 2. Teamwork KSA test



Course evaluations showed that the majority of students rated CL as good(4) or excellent(5) for meeting course objectives and helping them prepare for the examination. This method of instruction in the classroom, student laboratory or clinical laboratory has potential for addressing the needs of students who learn best by active learning.

Teamwork-KSA results indicated that the CL group members did not feel different about their ability to work well in teams after participating in CL activities or from any previous work experience. This suggests that students did not find it more difficult to work in teams once placed into a teaming environment (CL activities) than they had expected. Results of the lecture group show no differences on Teamwork-KSA pre and post tests indicating that students' perceptions did not change over time. Statistically the instrument showed that pre and post test total scores for both groups were nearly the same (see Tables 2 and 3). However, two subcategories of the Teamwork-KSA test showed some minor differences between the two groups. Self-management and collaborative problem-solving were somewhat statistically noteworthy and represent key skills necessary for good practice in the clinical laboratory.

CLS instructors must transfer a sizeable volume of information for graduates to be content knowledgeable and technically skilled, resulting in a curriculum packed with content. Implementing CL in an already 'overstuffed' curriculum may seem impossible. This is why some educators are apprehensive about using CL, because it is perceived to be a time consuming teaching technique.[4] Preparing CL activities does

Table 2. Statistical analysis for Teamwork-KSA

	Pre/Post test			Group/Time		
	F	*p* cal*	Partial eta^2	F	*p* cal*	Partial eta^2
Teamwork-KSA Total	.509	.484	.025	.998	.330	.048
Interpersonal skills subtotal	.007	.937	.000	.163	.691	.008
Conflict resolution	1.000	.329	.048	1.000	.329	.048
Collaborative problem-solving	.747	.398	.036	2.075	.165	.094
Communication	0.017	.899	.001	.017	.899	.001
Self-management subtotal	1.957	.177	.089	1.957	.177	.089
Goal setting and performance management	.215	.648	.011	3.441	.078	.147
Planning and task coordination	2.937	.102	.128	.024	.878	.001

*$p = 0.05$

require forethought and organization from the instructor. Once established, however, this style of instruction can be easily applied to the classroom, student laboratory or clinical laboratory. Moreover, student laboratories are an ideal setting for small groups of students to focus on a specific methodology or procedure. When implementing CL in any educational setting, students are actively learning by working and teaching one another.

Several limitations were present in this study including differences in instructors, prior immunology/serology knowledge of students, and the brief amount of time allowed for the intervention. Also, the study had low statistical power due to the small sample size. Not a limitation of this study, but a potential problem with CL is the free-rider effect. This occurs when one student participates minimally or not at all and reaps the benefits of the hard work of the other members of the group.[5,14-16]

Both past research and student comments from this study demonstrate that further exploration of CL use in CLS education is warranted. Future research should investigate the implementation of CL in courses with large volumes of content such as microbiology, chemistry, and hematology. As a supplemental instructional method, CL is an effective way for active learning to enter the traditional passive classroom. CL activities could be spread throughout a course and intermingled with lecture presentation. Ideally, CL activities should be used when topics require conceptualization, problem-solving, higher level reasoning, and critical thinking.

CONCLUSION

Educators in different fields agree that CL is a viable teaching approach for developing higher cognitive and affective skills and preparing students for participation in a team oriented environment.[1-6,17,18,25-32] Based on our results, the implementation of CL did not reduce students' achievement on a knowledge examination and may have provided some additional benefits related to teamwork skills. We conclude that the incorporation of CL with traditional lecture in the classroom student laboratory, or clinical laboratory could better prepare students for the real world environment of the clinical laboratory.

Authors Note: An earlier version of the data presented in this manuscript was presented as a poster at the Clinical Laboratory Educators' Conference, St Louis, MO, February, 2001.

APPENDIX

Examples of cooperative learning activities

ABC activity incorporates assigned readings or previously discussed material. 'A' in the ABC process requires students to spend five minutes thinking about a question and formulating an answer or position to be presented. In part 'B', students are paired up with a student with whom they have not worked. The pair spends five to six minutes discussing the question. 'C' in the ABC process involves two pairs joining together for a foursome. This small group comes to a consensus on the topic and presents their assignment to the class.[2]

Jigsaw is one of the most widely used CL activities. Each student is provided with a portion of the material: one piece of the jigsaw. The student becomes an 'expert' on his/her part of the instructional material. Then, each student teaches the other members in the learning group about his/her piece of the jigsaw.[2]

Roundtable activities allow individual student accountability in a non-threatening atmosphere. Students are seated in teams and circulate a pad as each student adds an idea or fact to the growing list. To increase communication skills, students say ideas out loud as they pass the pad around. Group ideas are shared with the class and a discussion is facilitated by the instructor.[18]

Structured problem-solving activity prompts student participation and peer coaching. Teams work on the same problem or issue that is projected on an overhead or a chalkboard. Each student is assigned a unique number within the team and the instructor selects a number designating the teams' spokesperson. The selected spokesperson presents their teams' finding to the class. Not all teams may present in class due to repetition and time constraints.[18]

Think pair share activity requires students to process new information from lecture or reinforce material from out of class assignments. The instructor poses a question and students must think and write appropriate responses. Ideally, the question proposed by the instructor should demand analysis, evaluation, or synthesis. Students pair up and discuss their responses. Pairs of students join together and share ideas, followed by discussion with the entire class. Confidence and oral communication skills are enhanced through this activity.[18]

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