An Odyssey into Cooperative Learning

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This study focuses on the use of the cooperative learning paradigm as a teaching method for a course traditionally presented in the lecture format. During the Fall 1995 semester Functional Group Analysis, a one credit course which serves as an introduction to medicinal chemistry, was taught in multiple sections using either the cooperative learning format or the lecture format. Students were evaluated on their ability to master the subject material as well as their preference for the new teaching method. The design of the cooperative learning course and the methods of assessment are discussed. In Fall 1996 the study was continued, but all students were instructed through the cooperative learning paradigm. The perceived benefits and limitations of this teaching method were assessed by both students and faculty. The results of this study indicate general acceptance of the teaching method by students, with a number of very positive perceived advantages. Quantitative evidence supporting cooperative learning as a better teaching method was lacking, but insufficient mechanisms of testing for evidence of greater success in reaching the expected competencies may be the problem. It appears that the test group of students were not at risk of learning less and did in fact develop skills extraneous to the subject material of the course in areas outside of factual knowledge.

INTRODUCTION

Colleges and schools of pharmacy with 2/3 or 2/4 programs are commonly faced with entering classes in which the students have varying academic preparedness for beginning the professional program. This seems especially true of the area of organic chemistry where students enter from doctoral granting research institutions, four year undergraduate programs, liberal arts colleges, and community colleges.

With the intent of bringing our students to a more uniform level of knowledge, a one credit course was developed nearly fifteen years ago entitled Functional Group Analysis (FGA). This course was offered as a required course which serves as an introduction to medicinal chemistry, was taught in multiple sections using either the cooperative learning format or the lecture format. Students were evaluated on their ability to master the subject material as well as their preference for the new teaching method. The design of the cooperative learning course and the methods of assessment are discussed. In Fall 1996 the study was continued, but all students were instructed through the cooperative learning paradigm. The perceived benefits and limitations of this teaching method were assessed by both students and faculty. The results of this study indicate general acceptance of the teaching method by students, with a number of very positive perceived advantages. Quantitative evidence supporting cooperative learning as a better teaching method was lacking, but insufficient mechanisms of testing for evidence of greater success in reaching the expected competencies may be the problem. It appears that the test group of students were not at risk of learning less and did in fact develop skills extraneous to the subject material of the course in areas outside of factual knowledge.

(ODYSSEY: A long wandering or voyage usually marked by many changes of fortune)

Assumptions are made throughout the literature that cooperative learning principles, methodologies, and findings are applicable across ages and learning contexts. Empirical and pragmatic studies related to cooperative learning are abundant, however most of this research involves children. The effects of cooperative learning at the college level are relatively few, most are of the practical application nature without controlled groups, and the results are not as consistent as those from elementary and junior high students. There are several examples of positive achievement effects of cooperative learning in senior high school and college settings. However, a number of adult implementation studies have failed to find differences on achievement measures between cooperative learning and control groups. It is generally agreed that for cooperative learning to be successful it should include: (i) small groups (3-5 students); (ii) individual group member assignments with specific roles; and (iii) heterogeneous grouping.

Purposes of the Study

The two major purposes of this study were to determine the effect of the cooperative learning (student centered learning) approach on the ability of pharmacy students to achieve the expected course competencies of FGA and to assess the benefits of cooperative learning as a course delivery method.
feel more comfortable in a class taught by a professor.”

cate their reason for reluctance to participate, several cited the additional work requirement and one student wrote, “I

comprised of two cooperative learning groups of approximately 50 students each and two control (lecture) groups of approximately 50

In the Fall of 1995,45 invitations were required to fill the 40 cooperative learning slots. All remaining students were sent a letter inviting them to participate in the cooperative learning section of FGA. The letter explained the additional time requirements, the nature of the student-centered activities, and the expected advantages of this learning experience. Additionally, a copy of the syllabus was enclosed. In the Fall of 1995,55 invitations were required to fill the 40 cooperative learning slots. All remaining students (n=100) registered for the traditional lecture course and were unaware at the time of registration of the special section of the course. Thus, the final study population was comprised of two cooperative learning groups of 20 students each and two control (lecture) groups of approximately 50 students each.

While most of the 15 individuals who chose not to participate in the cooperative learning group did not indicate their reason for reluctance to participate, several cited the additional work requirement and one student wrote, “I feel more comfortable in a class taught by a professor.”

### Table I. Course competencies for functional group analysis (FGA)

<table>
<thead>
<tr>
<th>The student will be able to:</th>
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<tr>
<td>1. list the properties (physical-chemical) of individual functional groups.</td>
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<tr>
<td>2. predict and draw the structures of chemical instability products of individual functional groups.</td>
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<tr>
<td>3. predict and draw the structure of metabolites of individual functional groups.</td>
</tr>
<tr>
<td>4. predict physical-chemical properties of a drug based upon the functional groups present in the drug: Water and lipid solubility, pH, in vitro chemical stability, reactivity with acid/base.</td>
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<tr>
<td>5. predict and draw the structures of chemical instability products of drugs based upon the functional groups present.</td>
</tr>
<tr>
<td>6. predict the metabolism of a drug based upon the functional groups present.</td>
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### Table II. Learning objectives and outcomes for the cooperative learning section of FGA

<table>
<thead>
<tr>
<th>Learning Objectives:</th>
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<tr>
<td>1. To develop a learning environment in which the student could teach himself/herself</td>
</tr>
<tr>
<td>2. Promote the learning process through peer teaching</td>
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<tr>
<td>3. To develop learning through problem solving</td>
</tr>
<tr>
<td>Learning Outcomes:</td>
</tr>
<tr>
<td>1. Promote active student learning</td>
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<tr>
<td>2. Develop problem solving skills in the student</td>
</tr>
<tr>
<td>3. Develop the team concept as a learning method</td>
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<tr>
<td>4. Promote the critical thinking process</td>
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**Additional Instructor’s Objective:** Determine the suitability of teaching Functional Group Analysis as a cooperative learning/student centered learning course

### Treatment

The cooperative learning groups participated in one three-hour session per week for one semester. Following the guidelines presented earlier, students were divided into four demographically heterogeneous teams of five students each. On a rotating and weekly basis the teams were given the following assigned tasks: Facilitator, Presenter, Recorder, and Team Liaison (See Table III for definitions of student’s responsibilities). Each week one team member did not have a specific assignment, but this person was expected to take the role of any absent team member. The format for the weekly meetings of the class consisted of: discussion within small groups of assigned pages in the text followed by group problem solving activities; team presentation of a solution to the problem with questions and answers from the whole class; and follow-up and conclusions by the faculty facilitator.

In order to maintain consistency between groups the tasks which each group were required to complete were closely scripted by the faculty facilitators(4). The scripting consisted of: (i) preparation of a detailed syllabus with reference to specific reading assignments students were expected to have read before coming to class; (ii) time limits placed on the group discussion; (iii) problem sets consisting of: four distinct problems-one for each team, which were distributed to the teams upon completion of the chapter discussion; and time limits for problem solving activities. The faculty facilitator was available to the teams for clarification and advice on how to approach the problem. In addition to solving their assigned problem, the team was expected to prepare the Presenter to discuss the solution to the problem with the class. The class and the Presenter’s team members were encouraged to both question the conclusions of the Presenter and defend the conclusions. Finally, the instructor had an opportunity to highlight key points from the chapter being discussed and the findings which the problem solving emphasized.

The comparison group was taught in a traditional lecture format using only the textbook. Classroom instruction was one-hour per week. Student participation was limited to brief comments or questions. Both the cooperative learning group and the comparison group were observed at random times during the semester by outside observers to ensure the fidelity of the treatment.

Assessment of the two study groups differed. The cooperative learning group was assessed using peer and self
The recorder has the responsibility of taking notes on the exam represented the primary focus of the traditional lecture. This section of the course measured students' rote knowledge. The declarative, procedural, and schematic knowledge sections were included to provide insight into whether cooperative learning activities were viewed as valuable by the students.

One month after completing the course, 66 volunteers participated in a follow-up exam. The exam was designed using a similar format as that used for the final exam with the exception that only declarative and procedural knowledge questions were asked. The follow-up exam was administered to determine any differences in information retention between the experimental group and the control group of students. Of the 66 volunteers, 23 had been in the cooperative learning group and 43 in the traditional lecture group.

RESULTS

The results of the final exam were analyzed using Students’ t-test for unpaired samples \(P=0.05\). No statistically significant differences were found for either the declarative or procedural knowledge portions of the final exam or the follow-up exam. However, qualitative data revealed that students in the cooperative learning group had a more positive attitude about the course and felt able to draw from the course the knowledge they needed to answer exam questions.

Responses of all students to the schematic knowledge question (What experiences have you had that allowed you to answer the Procedural Knowledge question?), which was asked only on the final exam, were tabulated. The responses indicated that students in the cooperative learning sections (37 respondents) relied on the FGA class [5], problem solving activities [11], and group learning [9] as the knowledge base for answering the questions. On the other hand, students in the traditional class (84 respondents) relied on the FGA class [63], textbook and workbook [31], and a mix of prepharmacy and pharmacy courses [50]. These students turned to sources outside of the class to help answer test questions while the cooperative learning students were able to draw on in class experiences to answer questions.

Course assessment in Fall 1995 made use of two different evaluation forms. The evaluation form designed specifically for the cooperative learning groups is shown as Appendix E while the standard college evaluation form administered to all FGA students is shown as Appendix F. When students were asked to rate their success in mastering the expected
The course developed in me problem solving skills
The team concept as a learning method was stressed in the course
The course stressed the learning process through peer teaching
The course is suitable for teaching as a student centered learning course
The course developed in me oral communication skills
The course developed in me written communication skills
The course developed in me facilitator skills
Would have done “better” (7), “the same” (5), or “not as well”(14) if in the traditional course.
Rate the peer method of learning vs. learning on your own

Student response
Even though quantitative exam results were not favorable, qualitative data from the participants in the cooperative learning classes were favorable (Table IV and VI). It is important to remember that the objectives of the course were not only to provide students with a refresher course in organic chemistry, it was also to help them develop successful peer relationships that would persist throughout their professional programmable II. Learning Objective 1, to develop a learning environment for self teaching, would seem to be supported by comments such as “I learned better,” “I learned faster,” and “the class forced me to be prepared.” Learning Objective 2, peer teaching, and Learning Outcome 1, active student learning, were strongly supported by the statements of the nine students who “enjoyed group interactions and learned from others” as well as the comment dealing with unique contributions that each member can make to the learning process. Survey items 3 and 10 in Table IV also indicated the students satisfaction with peer teaching in the cooperative learning setting. Learning Objective 3 and Outcome 2, dealing with problem solving, were directly addressed by several students who recognized the value of problem solving as a learning tool. Again, survey item 1 in Table IV shows student awareness of problem solving skills. The development of the team concept as a

In 1996 a Biology, Chemistry, and Math Skills Assessment was given during student orientation. The assessment, of limited scope (18 questions, only measured incoming knowledge in the areas of functional group identification, acid/base properties of functional groups, and chemical bonding of organic molecules. The average on the organic chemistry section was 50.7 percent. The format of this initial assessment did not match that of the post-test and was not used to measure improvement. It did, however further support previously held convictions of student weaknesses in chemistry.

### Table IV. Student assessment of cooperative learning in FGA in Fall 1995

<table>
<thead>
<tr>
<th>Survey item</th>
<th>Mean scores&lt;sup&gt;a,b&lt;/sup&gt;</th>
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</thead>
<tbody>
<tr>
<td>1. The course develop in me problem solving skills</td>
<td>4.43</td>
</tr>
<tr>
<td>2. The team concept as a learning method was stressed in the course</td>
<td>4.43</td>
</tr>
<tr>
<td>3. The course stressed the learning process through peer teaching</td>
<td>4.36</td>
</tr>
<tr>
<td>4. The course is suitable for teaching as a student centered learning course</td>
<td>4.14</td>
</tr>
<tr>
<td>5. The course developed in me oral communication skills</td>
<td>4.00</td>
</tr>
<tr>
<td>6. The course developed in me written communication skills</td>
<td>3.96</td>
</tr>
<tr>
<td>7. The course developed in me facilitator skills</td>
<td>4.18</td>
</tr>
<tr>
<td>8. The course helped me mastery the expected competencies</td>
<td>3.97&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>9. Would have done “better” (7), “the same” (5), or “not as well”(14) if in</td>
<td></td>
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<tr>
<td>the traditional course.</td>
<td></td>
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<tr>
<td>10. Rate the peer method of learning vs. learning on your own</td>
<td>4.24</td>
</tr>
</tbody>
</table>

<sup>a</sup> = poor, 5 = excellent.
<sup>b</sup>N = 28/40.
<sup>c</sup>1 = not at all, 5 = extremely well.
dealing with communication skills, it had been the expectation of the faculty that students would have an opportunity to improve their communication skills. It was rewarding to note that students enjoyed the opportunities to facilitate, to give oral presentations, and the weekly written reports improved as the semester progressed. Survey IV results 5-7 indicated that students felt that the cooperative learning section improved their communication skills. Finally, the general comments pointed out a need to reevaluate the organization of the course to better meet the needs of the students.

Due to the positive response to the cooperative learning format for FGA every section of the course was taught in a cooperative manner in 1996. The content was offered as a seven week, two sessions per week block as part of a three credit course titled Pharmacy Skills Program I. During the 1996 academic year adjustments were made in the assessment techniques, and students were coached on the importance of being able to learn and present process information. Performance on the same procedural knowledge final exam question used in 1995 increased from 37.7 percent to 65.8 percent in 1996. Unfortunately, the follow-up exam given at the beginning of the next semester did not show a similar increase in success. The student’s retention of knowledge on the same procedural/process question (different chemical structure) only increased from 30.4 to 37.8 percent, when comparing the 1996 to 1997 scores. It should be noted that in 1996-97 the final exam (class average 65.8 percent) did count toward the student’s grade while the follow-up exam (class average 37.8 percent) did not effect academic standing. These results may not be surprising since assessments not embedded in the curriculum with specific academic consequences would not be expected to provoke a strong student commitment to do well.

Student perception of the value gained from the 1996 cooperative learning experience is given in Table VII and although lower mean scores were reported than the previous year the results still support general acceptance. Written comments from the students indicate that FGA was a strength of the Pharmacy Skills Program I (13 responses), that more time was needed to cover the content or that the material should be presented over a longer period of time (seven responses) and that using a block of time to teach the subject in small groups was valuable (six responses).

**Faculty Perceptions**
The perception of the faculty of the value of the cooperative learning format was also assessed following the fall 1996
In summary, we were unable to show a difference in cognitive skills possessed by students who completed the FGA course through the cooperative learning format as compared to traditional lecture format, but did find qualitative differences in the students perceptions of what they had learned. The triad of course objectives as outlined by Sutherland and Bonwell are knowledge, skills, and attitudes (6). If the level of knowledge and skills are maintained in the cooperative learning experience and, at the same time, the student’s attitudes about learning can be positively influenced then we may have had a major impact on the students’ ultimate success in the professional program, as a member of the health care team, and as a life long learner.

**CONCLUSIONS**

APPENDIX A. PEER AND SELF EVALUATION FORM I

**Functional Group Analysis**

<table>
<thead>
<tr>
<th>Individual Making Evaluation</th>
<th>Participation</th>
<th>Cooperation</th>
<th>Level of preparation</th>
<th>Leadership</th>
<th>Apparent knowledge</th>
<th>Team work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student A</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student B</td>
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<tr>
<td>Student C</td>
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<tr>
<td>Student D</td>
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<td></td>
<td></td>
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<tr>
<td>Self</td>
<td></td>
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</tbody>
</table>

Scale: 5 = Excellent; 1-Needs considerable improvement.

Additional comments - Individual/Group:

Additional comments - Self evaluation:
APPENDIX B. PEER AND SELF-EVALUATION FORM

Date of evaluation __________ Individual making evaluation _________________________________

In making the evaluation consider the following: Participation in team discussion, ability to work as a team member, ability to cooperate with others, level of preparation and apparent knowledge, leadership ability, ability to speak plainly and loud enough to be heard. Remember you are being asked to make constructive criticism of your colleagues so that they can improve in areas in which they may be weak.

Student A ____________________________________________________________
Student B ____________________________________________________________
Student C ____________________________________________________________
Student D ____________________________________________________________
Self __________________________________________________________________

Additional Comments :

APPENDIX C. INSTRUCTOR ASSESSMENT FORM

Week 1 __________________________________________________________________ Week 2 __________________________________________________________________
Participation Facilitation Presentation Report Homework Participation Facilitation Presentation Report Homework


X = Student completed task.

APPENDIX D. SCORING SHEET

Procedural Knowledge II. Metabolism

Predict, with chemical structures, the metabolic products that could be formed when a 26 year old white male is administered Drug A. (Spell out the step wise process that you used in reaching your predictions.)

Compound A

Problem II (Metabolism):

Did the student identify a tertiary amine? Yes No
Did the student identify a secondary alcohol? Yes No
Did the student identify an alkene? Yes No
Did the student identify an ether? Yes No
Did the student identify a phenol? Yes No
Did the student identify an aromatic ring? Yes No

Tertiary amine:
Did the student indicate that this group underwent: Demethylation? Yes No
Was structure correctly drawn? Yes No

Alcohol (secondary):
Did the student indicate that this group underwent: Conjugation? Yes No
Oxidation? Yes No
Were structures correctly drawn? Yes No

Alkene:
Did the student indicate that this group is stable? Yes No

Aromatic ring:
Did the student indicate that this group underwent Hydroxylation? Yes No
Was the structure drawn correctly? Yes No

Ether:
Did the student indicate that this group is stable? Yes No

Phenol:
Did the student indicate that this group underwent: Conjugation? Yes No
Methylation? Yes No
Were structures correctly drawn? Yes No

Maximum Total Yeses 18 Total Yeses ____

APPENDIX E. COURSE EVALUATION

Functional Group Analysis

The stated goals for presenting Functional Group Analysis as a student centered course were:
A. Determine the suitability of teaching Functional Group Analysis as a student centered course
B. Develop problem solving skills in the student
C. Develop the team concept as a learning method
D. Develop the learning process through peer teaching

Please indicate as to whether these goals were met. On a scale of 1(poor) to 5(excellent) I believe that the course (comments are welcome):
1. Developed in me problem solving skills.
2. Developed the team concept as a learning method
3. Developed the learning process through peer teaching
4. Is suitable for teaching as a student centered learning course

You also had the opportunity to develop oral and written communication skills as well as facilitator skills. How well do you think you
In addition, certain competencies were expected to be met concerning organic chemistry. The competencies consisted of being able to predict physical-chemical properties of individual functional groups and of complex drugs, of being able to predict metabolites of individual functional groups and of complex drugs, and of being able to predict chemical stability of individual functional groups and of complex drugs.

8. How well do you think you have been able to master these skills (1 = not at all, 5 = extremely well)?
9. Do you think you would have done “better” , “the same” , or “not as well” in mastering the competencies if you had been in the traditional course?
10. Having had to learn the material on your own or through peer teaching how would you rate this method of learning?
11. If the course had been graded “S” or “U” would you have been willing to take this section of the course?
12. What did you enjoy the most about this course?
13. What did you enjoy the least about this course?

Feel free to add additional comments about the course: