

Piloting Case-based Instruction in a Didactic Clinical Immunology Course

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OBJECTIVES: To assess 1) the effect of case-based instructional modules on student critical thinking, class attendance, and satisfaction and 2) student opinion of case formats.

DESIGN/SETTING/PARTICIPANTS: University-based upper division course in clinical immunology and serology. The course was taught by the same instructor for two consecutive semesters with the intervention introduced in the second semester. Sixty-seven students experienced the intervention and 56 students were in the baseline cohort.

INTERVENTION: Nine cases were interspersed between lectures during the semester. Each case took one 50-minute class in which students worked in groups of five or six.

MAIN OUTCOME MEASURES: Student performance on five critical thinking multiple-choice examination questions and percent student attendance on case days versus lecture days were analyzed using the Mann-Whitney test. Student ratings on course evaluations were analyzed using t-test comparing semesters with and without intervention. Student opinion of cases was obtained through surveys and a focus group.

RESULTS: Student performance on critical thinking exam questions was similar in the two groups. Student attendance was significantly higher on case days (95.6%) versus lecture days (80.3%; $p < 0.0001$). Only composite ratings for instructor involvement, student-instructor interaction, and course organization were significantly improved in the semester with cases compared to the semester with lecture only ($p < 0.0001$ for all indices).

CONCLUSIONS: Although case studies did not significantly improve student performance on critical thinking questions, they still proved to be a valuable instructional method. Student attendance, student-instructor interaction, and instructor involvement in the course were all positively affected by incorporation of case studies. Discussion of cases also helped to uncover student misconceptions of course material.

ABBREVIATIONS: CL = cooperative learning; CLS = clinical laboratory science; Ig = immunoglobulin; PBL = problem-based learning; SIRS = Student Instructional Rating System.

INDEX TERMS: active learning; case-based instruction; cooperative learning; immunology.

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Lecturing is the predominant form of higher education instruction worldwide, yet it has some flaws that concern educators.¹ Lecturing is a teacher-focused method of instruction characterized by passive information delivery that typically fails to engage students. Students often take notes without processing the information, tending only to record random facts that they believe they need to memorize for an examination. Further, instructors have all experienced students who sleep, read newspapers, work crossword puzzles, or are otherwise completely disengaged with a lecture. Additionally, the average adult learner's attention lapses dramatically 10 to 18 minutes into a lecture, with lapses in attention occurring more frequently throughout the average 50 minute lecture.² Most important, compared to active-learning techniques, traditional lecturing fails poorly in student retention of information and development of student critical thinking and life-long learning skills.³ Despite these known deficiencies, lecture-based instruction is often maintained for a number of possible reasons: 1) faculty familiarity with what they experienced as undergraduates; 2) peer-pressure from colleagues who have always lectured; 3) ignorance of alternative instruction methods; 4) lack of institutional support for training in alternative instruction methods; 5) lack of published research demonstrating advantages of alternative instruction method in their particular discipline; or 6) economical savings of low faculty to student ratio in high enrollment lecture-based courses.

Problem-based learning (PBL) and cooperative learning (CL) in the form of patient case-based instruction are alternatives to lecturing that have gained considerable popularity in health science education, especially in medical school curricula. PBL and CL are similar methods of instruction that differ mostly in complexity and level of responsibility placed upon the learner. Both PBL and CL use learners working together in groups to accomplish tasks or activities. CL has been defined as “students working together to accomplish shared learning goals and maximize their own and their groupmates’ achievement”.⁴ CL techniques stress positive interdependence and try to eliminate student competition, especially within groups.⁴ The activities used for CL can be quite varied and have been summarized elsewhere.^{4,5} PBL is a highly advanced form of CL. Whereas CL can be used exclusively as an instructional method or alternatively integrated into lectures as enhancement activities, some strong advocates of PBL believe it should be used as the exclusive course delivery method.⁶

In health sciences education, PBL generally uses real-life patient cases as the focus of learning. In its purest mode, the responsibility for learning is placed on the students and the instructor is only responsible for presentation of a clinically-relevant problem and facilitation of student learning.^{7,8} Key features of PBL are patient case studies that are generally loosely structured and require the learners to use a preexisting knowledge base. The students analyze, research, and discuss initial case information, decide what the appropriate learning objectives will be, and then research and revise learning objectives until the case can be completed.⁷⁻⁹ For a more thorough discussion of passive and active learning and justification for use of CL and PBL in clinical laboratory science (CLS), the reader is referred to McEnerney (1999).¹⁰

The theoretical and practical application of CL and PBL to CLS education has been appreciated for more than a decade.¹¹⁻¹³ The goals of CLS instructors in choosing to use CL or PBL are varied and include: 1) increasing student achievement; 2) increasing student critical thinking and/or problem solving skills; 3) promoting teamwork skills; 4) fostering life-long learning skills; and 5) increasing knowledge retention.^{5,14-17}

The overall design of this pilot study was to incorporate case-based activities into a lecture course and assess the effect on several indicators of student performance and student satisfaction. The intervention reported here uses the patient case-based learning format of PBL but really should be considered CL as it falls short of the strict definition of PBL for two

reasons.⁷ First, the cases were not used exclusively as the only instructional method in the course, but were instead used to augment lectures with the intention of connecting concepts that the students were taught previously as discrete lecture elements. This was deemed necessary for this course since it is the only immunology course in the undergraduate curriculum and the students did not have a significant knowledge base to draw upon. Second, the students did not choose the learning objectives based upon the patient case presentation but instead were given specific questions by the instructor to answer within a single class period. Therefore, the most appropriate categorization is what Barrows refers to as the “case method” and what we will refer to as CL cases.⁹

The primary goal of this study was to assess whether CL cases would improve student performance on critical thinking level examination questions that required clinical application of basic immunology concepts. A secondary objective of the study was to collect student opinion of case format and implementation for subsequent optimization of case design within the course. Additionally, the instructor hoped to improve student attendance with the use of CL cases. Student performance was assessed on five analysis/application level multiple choice exam questions. Student attendance on CL case days was compared to attendance on lecture days for the intervention semester only. Data from student course evaluations of course/instructor satisfaction were compared for semesters with and without case-based CL intervention. Finally, subjective student evaluation of CL case design and implementation was collected by the use of a student survey and a retrospective focus group.

METHODS

Overall study/course design

The study of small group discussion of patient cases took place in a semester-long 3-credit junior/senior level undergraduate course in clinical immunology and serology with 67 students. The study was partially retrospective to a previous semester (the baseline semester) that was taught by lecture-only format using PowerPoint® presentations to a group of 56 students. In the subsequent semester, nine patient case studies were incorporated into this course as the intervention. The study was approved by the Michigan State University Committee on Research Involving Human Subjects. Students who took the course during the intervention semester were informed of the study and asked to sign a consent form. All except one student agreed to participate in the study. The course was taught during a standard 15-week semester, and met Monday, Wednesday, and Friday of

each week for 50-minute class periods. Four hourly exams were administered during the semester. Thirty class periods were used for standard lecture presentation of material. The initial one-quarter of the course material (prior to the first hourly examination) was presented using lecture only without cases. After the first examination, cases were scheduled for every Friday, with each case being related to the lecture material presented on Monday and Wednesday of the same week (when possible). Overall, nine case sessions were held. Detailed lists of learning objectives were provided for each lecture. Cases did not have specific learning objectives and material presented only via cases (and not in lecture) was not assessed on examinations.

Student group format

Twelve groups of five or six students each were assigned by the instructor and were fixed throughout the semester. Students were assigned to groups based upon incoming grade point average (distributed among groups), race, and gender. An effort was made not to leave any given student a 'single' in a group, e.g., only Caucasian female. Groups handed in only one answer sheet and each student in the group was required to sign the sheet verifying that they agreed with the answers and had actively participated in generation of the answers. One student had the role of 'note taker' each week and this role was required to rotate among group members from case to case. To encourage and account for balanced group member participation, each student had to assess fellow group members using a standard assessment form following every third case (peer assessment).

Case study content and design

The patient case studies were presented using a standard informational format and one of three possible delivery formats (see below). Cases were adapted from previously published case studies.^{18,19} Each case study had a patient identified by name, age, and gender. The patient history was given in a one to two paragraph summary that included presentation symptoms, physical examination details, and laboratory tests ordered. Family history was also provided if appropriate. Results of the laboratory tests were displayed on an overhead projector throughout the class period. Since laboratory testing was not covered in lecture, the instructor provided reference books that the students could use during class to investigate the laboratory tests and their reference ranges and significance. Each group then received one of four possible question sets provided in hard-copy. Group members had their desks arranged in circles to facilitate group conversation (approximately 30 to 40 minutes). Five to ten

minutes were retained at the end of the class period to allow for instructor debriefing of the most important questions the groups had addressed. Each group answer was worth a possible five points and case study grades accounted for 13% of the course grade. Each group member received the same grade as other members of that group. Students with excused absences were allowed to answer the case study questions individually outside of class for credit. Graded answers with comment were photocopied and returned to the students as soon as possible, usually by the next class session.

Example case

The following example case is provided so that the reader may understand the working definition of critical thinking application questions as used in the CL cases. This case is an example of agammaglobulinemia (the students were not given the diagnosis).

A two year old boy (Bill) presented to a pediatrician with pneumonia, recurrent bacterial infections, and no visible tonsils or palpable cervical lymph nodes upon physical examination. Laboratory results included a complete blood cell count with white blood cell differential (all normal) and total serum antibody results for immunoglobulin (Ig) G, IgA, and IgM. Serum antibody results were: IgG 200 mg/dL (reference range 600-1500 mg/dL); IgA <1 mg/dL (50-125 mg/dL); and IgM 10 mg/dL (75-150 mg/dL). The following are representative questions the students were asked to answer in groups:

1. List the abnormal laboratory test results.
2. Explain the differences in the degree of deficiency for the three serum antibody isotypes tested.
3. Based upon your answer for question 2, can you explain why Bill did not get ill until he was 10 months old?
4. Based upon the laboratory results, is it possible that Bill is missing a key white blood cell type? Identify this cell.
5. List as many possible protein mutations that could lead to the suspected deficiency.
6. Suggest the basis for the lack of detectable tonsils and cervical lymph nodes.
7. Suggest further laboratory testing that may be useful in determining the cause of Bill's recurrent infections.

Case study delivery format

The case delivery format was varied during the semester. The formats were: 1) students were read the case history by the instructor at the beginning of class, the laboratory results were presented on an overhead projector, and three to four topic-focused questions per group were handed out

to be completed in 30 minutes; 2) students were read the case history by the instructor at the beginning of class, the laboratory results were presented on overhead projector, and one in-depth question was handed out to each group to be completed in 40 minutes; or 3) students received a photocopy of the case history and laboratory results one week in advance of group discussion of the case, and three or four topic-focused questions per group were distributed at the beginning of class to be completed in 40 minutes. The slightly different formats were rotated in sequence across the nine Friday sessions utilized for CL.

Data collection and statistical analysis

Student critical thinking skills with and without case study intervention were assessed with five multiple choice examination questions that were repeated verbatim in both semesters (examinations are not returned to students). The questions were categorized as critical-thinking-type questions since they required analysis and/or application of course concepts and could not be answered by memorization. One of the critical thinking questions used was:

A patient presents to his/her physician with recurrent infections caused by extracellular bacteria. The patient does not appear to be susceptible to other infections. What immune defect would likely be the cause?

- a. Defect in antigen presenting dendritic cells.
- b. Defect in class I expression on all body cells.
- c. Defect in class II expression on thymic cortical epithelial cells.
- d. Antibody deficiency due to B cell deficiency.

Individual student performance (number correct out of five possible) for all students in the baseline group and the intervention group was recorded. Statistical analysis was performed with a Mann-Whitney nonparametric test for differences between the medians. A t-test could not be performed because the data were not normally distributed. Statistical significance was set at $p < 0.05$ for this and all other statistical analyses.

Student opinion of the impact of case studies on increasing student level of comfort with course material and student understanding of course material was surveyed four times during the intervention semester (with each examination). A Likert scale ranging from 1 (superior) to 5 (inferior) was used for recording student opinion. The scores (mean and SD) for the four surveys were used to perform linear regression analysis.

Student Instructional Rating System (SIRS) surveys used for campus-wide course/instructor evaluation were used to assess the effect of case studies on overall student satisfaction with the course. The SIRS consists of 21 questions assessed by a Likert scale ranging from 1 (superior) to 5 (inferior) and provides composite profile factor scores for multiple questions related to a theme (instructor involvement, student interest, student-instructor interaction, course demands, and course organization). In this study, composite profile factor scores were compared for semesters without and with intervention using an unpaired t-test. Additional survey questions pertaining to case studies were added to this survey for the intervention semester only, with forced response choices listed (3 to 5) for each question (non-Likert scale).

Aggregate student attendance was taken by head-count 10 to 15 minutes into the class period to allow for latecomers. Percent attendance on days of scheduled lecture versus days of scheduled case study work was compared by the Mann-Whitney test. A t-test could not be used since the variance in the groups was not equal.

A representative sample of students (13 of 67 total students) from the semester of the CL case intervention was recruited to participate in a focus group. The focus group was conducted by a professional with considerable previous experience with moderating focus groups, but who was previously unknown to the students. The instructor was not present at the focus group, but students were aware that the session was audio-taped, and would be transcribed without speaker identification, for documentation purposes.

RESULTS

Class attendance

Daily aggregate class attendance was recorded 10 to 15 minutes into the class period for each day during the semester with CL case intervention. Class attendance on CL case days was significantly higher than on lecture days (Figure 1).

Critical thinking skills

The primary goal of adding the CL cases to the course was to improve student critical thinking skills. Student performance on critical thinking examination questions for the intervention semester (lecture + CL cases) was not significantly different from the baseline semester (lecture only; Table 1).

Student opinion of case impact

Student surveys were administered several times during

the semester to obtain student opinion of the effect of the case studies on two aspects of course material acquisition. Student-reported opinion of their comfort level with course material improved significantly during the course (2.66 to 2.24; $r^2 = 0.907$; $p = 0.047$). Student opinion of understanding of course material attributed to the case study also improved, but was not statistically significant (2.55 to 2.28; $r^2 = 0.812$; $p = 0.098$) (Figure 2).

Mean scores on end-of-course student evaluations of satisfaction with course/instructor were compared for the semesters with and without CL case intervention. Composite scores for three of five profile factors were significantly higher for the semester with CL case studies compared to the semester

without case studies (Table 2). The scores for instructor involvement, student-instructor interaction, and course organization improved significantly for the intervention semester compared to the baseline semester. Scores for student interest and course demands did not change significantly.

Student case format preference

Student opinion of case delivery preference and case utilization was obtained through forced-response survey questions and a focus group. Cases were delivered using three formats during the semester. Students overwhelmingly preferred the format in which patient case background was provided one week in advance of in-class scheduled group work sessions (Table 3). Open-ended questions in the focus group on strengths and weaknesses of the cases and case design revealed that: 1) students valued the case activity because it allowed them to observe peers' thought processes; 2) answering case questions forced students to clarify the material better than they would if they only studied on their own; and 3) peer evaluation was important to ensure the group work was equitable. Students in the focus group also commented on

Figure 1. Mean percent class attendance was significantly higher on scheduled CL case days versus scheduled lecture days during the intervention semester

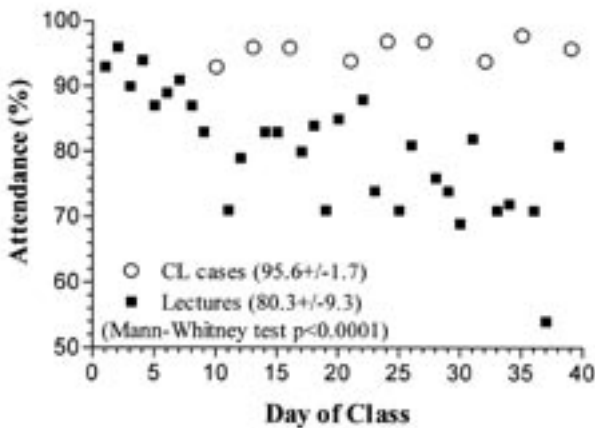


Table 1. Student performance on multiple choice critical thinking exam questions

	B*	I†
Students examined (n)	53	66
Mean‡	3.132	3.106
SD	0.921	1.025
p value§		0.798

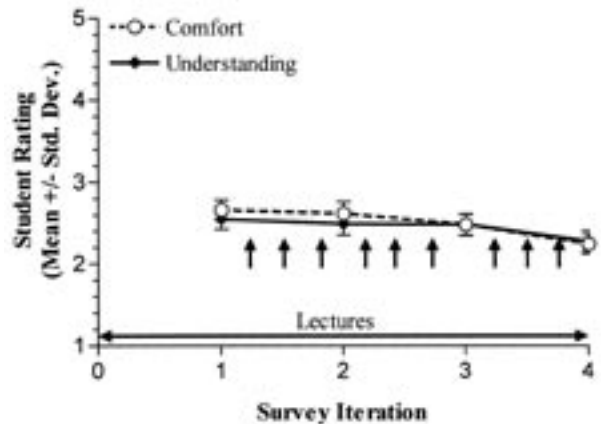
* Baseline semester(lecture only)

† Intervention semester (lecture + CL cases)

‡ Number correct out of five total questions

§ Mann-Whitney nonparametric test for differences between medians

Figure 2. Student comfort level with and understanding of material



Self-reported student comfort level with course material improved significantly during the intervention semester, but student-reported understanding of course material was not significantly affected during the intervention semester. Students were asked the following questions to address comfort level and understanding: 1) To what degree do the small group exercises increase your level of comfort with the course material? 2) To what degree do the small group exercises increase your understanding of the course material? A Likert scale of 1 (superior) to 5 (inferior) was used for the survey which was administered in 4 iterations during the semester. CL case study occurrences are indicated by ↑.

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the cases being scheduled on Friday, and that this allowed a welcome change of pace. However, they also commented that if the cases were not mandatory (points assigned toward grade), they would not have attended on Friday. Instructor observations of case studies are summarized in Table 4.

DISCUSSION

The primary impetus for addition of CL cases to the course was to promote student acquisition of critical thinking skills through the use of active learning techniques. Analysis of student performance on critical thinking level examination questions suggests that this goal was not achieved since there was no significant difference in student performance on these questions for the baseline and intervention semesters. However, the analysis is limited in power since only five questions were used to compare critical thinking skills. This limitation was due to the pool of critical thinking level examination questions available for reuse from the baseline semester to the intervention semester. Since the instructor did not intentionally teach critical thinking skills in the baseline semester, there were few such questions used on the examinations for that semester. Additionally, the assessment

questions used (multiple choice) did not match the format of the CL cases, in which the students were asked to draft short written answers to open-ended questions. This mismatch in instruction and assessment formats as well as the limited power of the measure may have limited the ability to detect possible true differences in critical thinking skills that may have been fostered by the CL cases.

A drawback of the current implementation of CL cases that may have interfered with the development of student critical thinking skills was the limited time for students to review and critique their group answers to the case questions. In particular, they had very little time to compare their group answers to those of their peer groups which had the same question sets. In addition, the students were not given an opportunity to critique and revise any of their answers following open class discussion of the questions. The cases were completed in one class session and the following class session was either a lecture or examination with no reference back to the CL case. Well-designed and executed PBL has adequate time for reiteration and reflection that is thought to be essential to ensuring recall and application of the information

Table 2. Composite scores for indicators of student satisfaction

Composite profile factor	Baseline semester	Intervention semester	<i>p</i> value
	(lecture only)	(lecture + CL cases)	
	mean/SD	mean/SD	
Instructor involvement	1.89/0.20	1.63/0.16	<0.0001
Student interest	1.83/0.12	1.88/0.21	0.20
Student-instructor interaction	2.15/0.19	1.90/0.13	<0.0001
Course demands	2.31/0.08	2.28/0.07	0.11
Course organization	2.05/0.19	1.77/0.19	<0.0001

Composite scores for three of five indicators of student satisfaction with course/instructor improve significantly in intervention semester with CL case studies (1 = superior, 5 = inferior; mean/SD reported).

Table 3. Students preferences for case delivery*

Case delivery format	Student preference (%)
Case read aloud, three to four topic-focused questions, 30 minutes to answer	2
Case read aloud, one in-depth question, 40 minutes to answer	27
Cases handed out one week prior, three to four topic-focused questions, 40 minutes to answer	59

*Percent is <100 because 12% of students did not answer the survey question.

to new but similar problems.⁷ Therefore, the lack of time for reiteration and reflection may have prevented gains in student critical thinking skills.

The lack of significant effect of CL cases on student critical thinking skills reported here is not completely unexpected. Other reports on studies of CL or PBL effect on student critical thinking skills for courses within CLS curricula have varied in results. Two of these studies had design limitations. One of these studies used groups only for completion of course examinations instead of for student “knowledge construction”.¹⁶ This is not a generally accepted method of CL and may have hampered any intended benefit of group work. The second study in which student examination performance was analyzed was limited by two factors.¹⁷ First, the PBL activity was only six weeks in duration and was not continued through the following year of instruction prior to examination. Second, the data presented were from student performance on certification examinations in which the majority of questions are recall level and do not test critical thinking skills. A third study by Bose was well-designed and rigorously used CL techniques but failed to show any significant difference in mean examination scores of students instructed with CL versus lecture.⁵ Additionally, this same study failed to show any differences in students’ perception of teamwork knowledge, skills, and ability.

Positive effects of PBL in CLS education are limited to two reports of subjective faculty evaluation of student critical thinking skills and learning motivation.^{14,15} Although faculty who use CL and PBL generally believe that these instructional methods enhance student critical thinking skills, the studies reported here and elsewhere do not seem to support that view. However, we support an alternative conclusion, which is that these studies failed to show significant differences in critical thinking attributable to CL or PBL because the measures

used to assess critical thinking skills were inadequate. Since discipline specific critical thinking skills require discipline specific knowledge, students may answer a question designed to measure critical thinking skills incorrectly if they lack the relevant knowledge.³ It may be that significant gains in critical thinking skills have been made in CL or PBL versus lecture, but we have been unable to adequately assess those skills.

The current study shows that class attendance was significantly higher on CL case days compared to lecture days. It may also be observed that class attendance decreased as the semester progressed and that attendance tended to be lowest on Fridays. General observation by the instructor also suggests that attendance on lecture days was improved compared to previous semesters. However, this point cannot be objectively tested since attendance was not recorded for the baseline semester, and the class met at a different time of day for the baseline semester. Although a statistical difference in attendance was demonstrated for case days compared to lecture days for the intervention semester, one must keep in mind a serious confounding factor: the students received 13% of their course grade from case studies, and attendance and group participation was mandatory to earn these points. Indeed, students commented in the focus group that many would have skipped class on Friday if case study participation were not mandatory. In retrospect, it seems that scheduling of the cases on Fridays was fortuitous. Since the instructor was hoping to increase student attendance with the use of CL cases, future use of CL cases will continue to encourage CL case participation through point incentives and to schedule cases on Fridays.

An additional and not wholly unexpected benefit of CL cases was significantly improved composite course/instructor ratings for instructor involvement and student-instructor interaction. Traditional lectures do not encourage students to ask questions or comment on the material in the classroom. The small group format of the CL cases may allow students to crystallize concepts and questions in their group with their peers prior to consulting the instructor, if that was deemed necessary. Once a dialog was initiated in the small groups, it appeared that students were freer to ask questions during the lecture and outside of their groups, thereby improving overall student-instructor interaction and the ability of the instructor to become more involved with the student’s learning.

The opportunity to discuss course material in small groups of students also appeared to improve student perception of their comfort and understanding of course material. Student opinion of their comfort and understanding due to CL cases improved

Table 4. Instructor observations on the use of CL cases

Cases in groups made it exciting to be in the classroom
 Case discussion assisted identification of student misconceptions
 Overall class attendance increased even on lecture days
 Case studies got students talking and initiated more questions in lectures
 Proper design and implementation of CL cases is time-consuming, but worth it

during the intervention semester when several iterations of the same survey were administered with three CL cases occurring between each survey iteration. This improvement was only statistically significant for student comfort with course material and not student understanding of course material. However, it should be noted that caution must be used in interpretation of significance for the linear regression analysis presented, as there is a possibility of a type I error since responses of individual students could not be tracked over time (surveys were anonymous). Additionally, the students reported relatively positive effects of CL cases for both comfort and understanding before any CL cases had actually taken place (they were verbally instructed to anticipate the effect of the CL cases on these aspects of the course). This may indicate that the students viewed the CL cases relatively positively even before they had experienced them, and this positive opinion was upheld once they had experienced them. An equally possible explanation is that the lecturer was very skilled and that the students became more comfortable with the course material during the course of the semester due to superb lecturing that was unrelated to the CL case experience. However, student comments during the focus group session support the former explanation more than the latter, or a combination of both.

One of the limitations of the reported CL case design discussed above was the lack of time for student reiteration and reflection. This was viewed by the instructor as a significant flaw in the CL cases. As a result, when CL case activities are used again for the same course, the instructor plans to devote two consecutive class sessions to each CL case. The first class session will have the students meet in groups to answer the case questions (as currently described). The second additional class session will entail class-wide discussion of student group answers to all of the questions followed by 10 to 15 minutes for groups to revise their written answers to their questions for additional points.

Although this study found that utilizing CL cases had no effect on student critical thinking skills, the instructor is still enthusiastic about using this instructional method again. Due to the limitations in the way in which critical thinking skills were assessed in this study, it may be that student critical thinking skills did indeed improve and that we were unable to detect it. Additionally, student comments in the focus group were very positive regarding the CL cases. The majority of students enjoyed working with their peers and valued the CL cases for a variety of reasons. The instructor also enjoyed the CL case activities and observed several advantages of the instructional method (listed in Table 4), some of which were not anticipated prior to use of the CL

cases. As a result, the CL cases will continue to be used in upcoming semesters with some minor modifications to the design as discussed above.

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