ORIGINAL ARTICLES

Teaching with Cases to Enhance the Clinical Problem-Solving Skills and Integration Skills of Fourth-Term Chiropractic Students

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The purpose of this project was to implement lecture-based cases into the traditional lecture time to see if it would enhance the students' problem-solving and integration skills and their ability to retain information. The project involved two different classes of fourth-term chiropractic students from the spring and fall 2000 trimesters in a course entitled ``Clinical Orthopedics and Neurology I,'' a neuromusculoskeletal diagnosis course. The Spring class (66 students: 16 females and 50 males) was the control group and received a traditional 2-hour lecture each week. The fall class (81 students: 18 females and 63 males) was the experimental group and received 1 hour of traditional lecture combined with 1 hour of clinical cases in the 2-hour per week time block. The entering grade point averages and units for the two groups were compared to ascertain if there were statistically significant differences between the two groups. *t*-Tests were used to measure how each class performed on three multiple-choice examinations. The examinations included two types of questions, those that evaluated knowledge/recall and those that evaluated integration. The *t*-tests assessed what percentage of each group answered all the questions correctly, what percentage of each group answered the knowledge/recall questions correctly, and what percentage answered the integration questions correctly. In addition, a satisfaction survey was developed and given to the experimental group. There were no statistical differences between the control and experimental groups at baseline. In evaluating the first examination, no statistical difference was found between the two groups ($p = .6$). On the second examination, a statistical difference of 4% was found ($p = .025$) on how both groups performed on the test. On the final examination, a statistical difference of 2% was found ($p = .19$). However, there was no difference on the students' performance on the knowledge/recall questions ($p = .98$). The difference of 4% was found in their performance on the integration questions ($p = .02$). The survey indicated that the students enjoyed the unfolding cases; they found them to be more challenging, they helped with both recall and integration, and they felt they were relevant to their future practice experience. The students were split as to whether teaching with cases required more study time or not. The results supported the hypothesis that the students' ability to integrate information would improve, but did not support the hypothesis that their ability to retain basic knowledge would improve. A follow-up study (i.e., retention test) between the two groups would be necessary to show if a significant difference exists in their long-term ability to retain knowledge and integrate information. A satisfaction survey indicated that the students preferred teaching with cases to traditional lectures. (The Journal of Chiropractic Education 15(2): 53–60, 2001)

Key words: active learning, case-based teaching, decision-making, integration, problem-based learning, teaching methods

INTRODUCTION

In chiropractic education at Southern California University of Health Sciences (Los Angeles College of Chiropractic) the primary teaching method being utilized is the traditional lecture format. The students matriculate for 15 weeks in a course entitled "Clinical Orthopedics and Neurology I" (CON I) which occurs at the beginning of their 2nd year in school. In CON I the students are taught to diagnose and manage neuromusculoskeletal conditions involving the low back and lower extremities, as well as other

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neurological and vascular diseases which may affect the body. An analysis of the students' examinations demonstrated that they typically perform better on knowledge-based questions and worse on case-based (integration) questions. Since the students are 1 year from a clinical internship, there was concern that they had greater difficulty with case-based (integration) questions.

Several discussions were held with students on why they had difficulty with case-based questions. The typical response was that they were not taught to think critically and dissect a case because they were taught facts in lectures and therefore questions involving memorization were much easier.

Another area where student difficulty with cases had been noticed was in the Campus Chiropractic Health Center (CCHC). When our students are in their 7th trimester (beginning of their 3rd year at school), they start their clinical internship in a clinician-based program. The clinicians were noticing a deficiency in the students' ability to problem solve and integrate the information being obtained from the patient population. Barrows states that students should be able to extend or improve on their knowledge base to keep contemporary in their eventual field of medicine and to provide appropriate care for the new or unique problems they may face in their work (1). The clinicians believe the students have not been exposed to problem solving early enough nor often enough, and this lack of exposure was interfering with their progress when it came to diagnosing and managing a patient.

According to Engel, the skills of diagnosis and treatment planning require application of preexisting knowledge, which can not be acquired in the passive and noninteractive environment of a lecture hall (2). In order to create interaction and active learning, a change was implemented in the way that lectures were presented. The goal was to simulate real-life clinical situations in the classroom without significantly increasing student stress. Keeping stress levels low is important because studies have shown that intense pressures and demands of school can have detrimental effects on academic performance, physical health, and psychological well-being (3). The research literature suggests several ways in which to do this: standardized patient, case-centered lectures (unfolding cases) and computer-based patient simulations (4–7). Students who have utilized one of these three formats reported that compared to lectures the learning experience was more enjoyable, less stressful, and an effective way to learn (7).

Case-based teaching utilizing unfolding cases was the method chosen for implementation. According to Barrows, in a lecture with cases format, the teacher presents the students with information in lectures and then a case or two, usually vignettes, to demonstrate the relevance of the information (8). This format is not true problem-based learning. However, it does encourage the generation of a hypothesis, data analysis skills, and some decision-making skills (8). Case-based teaching has received many positive remarks. The University of Virginia School of Medicine started a case-based format in 1985 for a course titled "Introduction to Clinical Medicine." A review of performance of the students on standardized examinations showed an improvement with the case-based format as well as a positive rating by the students in its ability to train them clinically (9). Schwartz et al. (10) reviewed case-based and traditional curricula from several different medical schools and found that the largest differences in satisfaction were in terms of promotion of student enthusiasm for learning, development of skills in independent learning, and development of problem-solving skills that occurred in the courses based on cases.

Newble and Entwistle proposed a model of learning where students are described as using three different approaches to studying in preparation for their assessments: "surface," "deep," or "strategic/achieving" approaches (11). Students who adopt the "surface" approach are predominately motivated either by a desire simply to complete the course or by a fear of failure. Students who adopt the "deep" approach are predominately motivated by an interest in learning for its own sake and an interest in the subject material by attempting to understand the underlying structure and meaning. Students who adopt the "strategic/achieving" approach are predominately motivated by the achievement of high grades and a sense of competition (12). Case-based courses were most frequently selected as requiring a style reflecting a "deep" approach, and the traditionally taught courses were most frequently selected as requiring a "surface" approach to the material (10).

Cased-based teaching is a method to provide students with the tools of clinical problem solving. It also provided a different form of stimulation to keep them actively engaged in their own learning and hopefully turn them into lifelong learners. According to Stolovitch, cases are a simulation that facilitates the transfer of skills to operational settings, whereby

participants develop skills in identifying, analyzing, and solving problems. This approach marries theory to practice (5). Students who are able to do this will learn how to continue as self-directed learners who have the desire and ability to learn independently throughout their careers, regardless of eventual specialty (13).

Another problem faced when teaching is the lack of integration of the basic sciences with the clinical sciences. Case-based teaching is one method that can enhance integration of the basic and clinical sciences. The rationale behind this emphasis was a belief that much of the basic science information can be applied when students participate actively in the process of acquiring new knowledge associated with clinical conditions (6). Inability to recall information stored in memory is due to lack of organization and understanding and cases help the learner organize and index the information better (14). A review article on learning stated that three factors help in the acquisition of knowledge: 1) Activation of prior knowledge facilitates the subsequent processing of new information; 2) elaboration of knowledge at the time of learning enhances subsequent retrieval; and 3) matching context facilitates recall (15). With cases, the students will be accessing information on the basic sciences in order to problem solve the case; they will be building on their existing basic science knowledge with clinical signs and symptoms of a condition during the discussions. Also during the cases the students are talking about clinical signs and symptoms, mechanisms of injury/illness, and the patient's dress and attitudes. These various attributes about the cases may make it easier for the student to remember facts later on in their education or when they encounter other clinical cases (15).

Utilizing the information from the literature and the input from the students, a case-based teaching project was implemented for the fall of 2000 in my CON I course. The goal of the project was to enhance the students' clinical problem-solving skills, retention of information, and their ability to integrate the information by combining traditional lecture style teaching with case-based teaching.

METHODS

Subjects

Subjects were students enrolled in CON I for two consecutive terms when the course was offered in the spring and fall trimesters. The control group was the spring of 2000 class made up of 66 students, 24% female (16) and 76% male (50). The experimental group was the fall of 2000 CON I class made up of 81 students, 22% female (18) and 78% male (63) students. The ratio of females to males was similar in both groups. The control group started in January of 2000 and finished in April of 2000 and the experimental group started in September of 2000 and finished in December of 2000.

Since this is a study comparing two existing populations of students, there were several variables that could impact the results; therefore, it was necessary to ascertain if there was a significant difference between the control and experimental groups. The variables that were investigated were:

- Entering grade point averages (GPA) for each student in the university
- Number of units each student had obtained prior to entering the university

Intervention

The course was 15 weeks long and had one 2-hour lecture and two 2-hour labs per week. During the 15 weeks, there were 12 lecture/case presentations and three written multiple-choice examinations. Only the format of lecture presentations was changed between the two courses. Both groups received identical lecture notes for the entire term, although the experimental group was asked to review the lecture notes prior to attending lecture each week. The control group received a traditional approach to teaching, which consisted of 2-hour lecture sessions for a total of 24 hours of lecture. The experimental group received traditional lecture combined with case-based teaching. The 1st hour of each session was a traditional lecture that covered the more difficult concepts regarding the topic. This traditional lecture was performed to satisfy the learner who was more comfortable with traditional lecture. The 2nd hour was case-based teaching utilizing an unfolding case format presented in a PowerPoint slide presentation; therefore, the experimental group received 12 hours of traditional lecture and 12 hours of cases.

Cases for each lecture topic for the fall trimester were written over the summer 2000 trimester. Teachers generally want a case to include the most typical signs and symptoms of the disease and the cases must contain enough information so those students can make crucial decisions and use clinical reasoning. The cases must also reinforce existing

knowledge and permit transfer of knowledge (16). The students were instructed on how the course would be run in their first class session. Rules were established on how the case discussions would progress. The main rules are as follows:

- Everyone must participate.
- Raise hand before speaking.
- Don't interrupt when someone else is speaking.
- The environment must be safe so that everyone will feel free to participate; therefore, no laughter or signs of disrespect will be allowed when others are speaking.

Evaluation

Both groups were evaluated on their performance on three different occasions utilizing three identical multiple-choice scantron examinations. Each exam had questions that assessed their knowledge/recall and their ability to integrate information. The first examination occurred in the 5th week of each trimester and consisted of 55 questions. There were 31 questions that primarily tested knowledge/recall and 24 questions that assessed their ability to integrate. The second examination occurred in the 10th week of each trimester and consisted of 70 questions. There were 45 questions that assessed knowledge/recall and 25 that assessed integration. The final examination took place in the 15th week of each trimester and had 70 questions. There were 46 questions that assessed knowledge/recall and 24 that assessed integration.

Several different analyses were performed on each examination. Immediately following the examinations, the scantrons were graded and an item analysis was performed which provided the percentage of each group that answered each question correctly. Utilizing this information, *t*-tests were performed that compared the mean scores of the percentage of the students who got all the items correct for each examination, the percentage who got the knowledge/recall items correct, and the percentage who got the integration items correct. Additionally, the three examinations were combined into one 195-item examination and *t*-tests were performed that compared how each group performed on the entire test, how each group performed on the knowledge/recall questions, and how each group performed on the integration questions. Finally, a satisfaction survey (Table 6) was distributed to the experimental group in the 13th week of the trimester. The survey was developed using sample survey questions from the literature as a template (2, 17). Only the experimental group received the survey because most of the questions on the survey were in regard to the cases and this did not apply to the control group.

RESULTS

GPA and Units

An analysis of the entering GPA and units of the two groups did not demonstrate a statistical difference between the groups on these two variables (Table 1). It should be noted that six records (GPA and entering units) from the experimental group and four records from the control group were not included in this analysis. These records were unavailable, because the students fell into a category known as "special students." This means that there were either academic, behavioral, or learning disability issues associated with the students and their files were restricted.

Examination Results

The results from the *t*-test on the first examination can be found in Table 2. These results indicate that there were no statistical differences between how the two groups performed on the examination. However, the experimental group performed four percentage points better on the integration questions than the control group.

Table 3 contains the results from the *t*-test on the second examination. These results indicate that a statistically significant difference was found in the examination ($p = .025$). The experimental group did four percentage points better than the control group.

The results of the final examination can be obtained in Table 4. The overall results of the examination indicate that there was no statistical difference between the two groups ($p = .19$). However, a statistically significant difference was found in the integration questions ($p = .02$).

A final *t*-test was performed on the combined test items (195 questions) from all three exams (Table 5). There was statistical significance in the overall performance ($p = .03$) between the two groups and in how the groups performed on the integration questions ($p = .05$) but not on the knowledge/recall questions.

Survey Results

The results of the student survey can be found in Table 6. The results are in percentages and the

Table 1. Comparison of Entering GPA and Units

	Experimental group (*n*)	Control group (*n*)	Difference	*p* value
Mean GPA	2.99 (78)	3.04 (63)	.05	.4
Mean Units	138.2 (78)	136.0 (63)	2.2	.72

Table 2. Results from the First Examination

	Experimental group (*n*)	Control group (*n*)	Difference	*p* value
Mean for all questions	73%(55)	72%(55)	1%	.6
Mean for knowledge/recall questions	72%(31)	72%(31)	0%	
Mean for integration questions	75%(24)	71%(24)	4%	.4

Table 3. Results from the Second Examination

	Experimental group (*n*)	Control group (*n*)	Difference	*p* value
Mean for all questions	75%(70)	71%(70)	4%	.025
Mean for knowledge/recall questions	77%(45)	71%(45)	6%	.069
Mean for integration questions	73%(25)	70%(25)	3%	.11

Table 4. Results from the Final Examination

	Experimental group (*n*)	Control group (*n*)	Difference	*p* value
Mean for all questions	70%(70)	68%(70)	2%	.19
Mean for knowledge/recall questions	67%(46)	67%(46)	0%	
Mean for integration questions	74%(24)	70%(24)	4%	.02

Table 5. Results from the Combined Test Items

	Experimental group (*n*)	Control group (*n*)	Difference	*p* value
Mean (combined test questions)	73%(195)	70%(195)	2%	.03
Mean (combined knowledge/recall questions)	72%(122)	70%(122)	2%	.24
Mean (combined integration questions)	74%(73)	70%(73)	4%	.05

columns of "Strongly agree" and "Agree" were collapsed into one column and the columns for "Disagree" and "Strongly disagree" were collapsed into one column. Seventy-eight surveys were filled out by the experimental group; three students were absent on the day in which the surveys were distributed. In addition to assessing satisfaction, the survey looked at frequency for which attendance at lecture occurred. Ninety-four percent indicated that they either always or often attended lecture and 6% indicated that they either occasionally or never attended. For question 4, one survey had both 3 and 4 circled so neither was counted. Question 9 was not answered on one subject's survey and question 11 was not on another survey.

DISCUSSION

The original hypothesis was that students who received case-based teaching would have better retention of knowledge and that their integration

Table 6. Student Survey and Their Responses

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
1	2	3	4	5

This method of teaching:	*1/2*	*3*	*4/5*
1. Improved my ability to problem solve.	83%	10%	6%
2. Improved my ability to retain clinical information.	85%	12%	6%
3. Provided me with a format to discuss the conditions with my classmates.	62%	26%	13%
4. Fostered greater interaction with my instructor.	53%	29%	17%
5. Was more interesting and enjoyable.	67%	27%	6%
6. Was more challenging.	85%	14%	4%
7. Helped me understand course content better.	86%	6%	8%
8. Required more study time than I normally need with traditional 2-hour lecture courses.	49%	21%	31%
9. Enabled me to better integrate basic science information with clinical science information.	69%	26%	4%
10. Enabled me to better integrate this course's material with other courses in the 4th trimester.	67%	27%	6%
11. Is more relevant to my future practice.	81%	10%	8%
	Always/Often	*Occasionally/Never*	
12. Frequency of lecture attendance	94%	6%	

skills would improve than those students who received a traditional lecture. When starting a new teaching innovation, there is generally a concern that the students will not perform as well as the students who received the standard lectures. This was a concern for this study. However, the overall results from this innovation were positive. There was a statistically significant difference in how the two groups performed on two of the three examinations, with the experimental group performing better overall. When analyzing the examinations further, it was found that the statistical difference primarily came from how the students responded to the integration as opposed to the knowledge/recall questions. A question that has yet to be answered is whether the statistical difference found between the two groups on two of the three examinations has any practical difference. Basically, there were only between one and four percentage points difference between the two groups on the three examinations. So even though statistically there was an improvement, practically the difference does not mean much. The results support one aspect of the hypothesis: that students who received case-based teaching would perform better on integration than those who did not receive case-based teaching.

The survey results indicated that the students liked case-based teaching. More than 80% of the experimental group either strongly agreed or agreed with the items pertaining to enhanced ability to problem solve, retention of clinical information, understanding information, and relevance to future practice. They also felt that the course was more challenging, which could be interpreted from either a positive or a negative prospective in that the cases made them think more and work harder. More than 60% either strongly agreed or agreed with the items pertaining to interaction with their peers, enjoyment, and integration. Only 53% of the students thought there was greater interaction between the instructor and themselves. The final item asked whether the students thought that cased-based teaching required more study time than traditional. The results were mixed in that 49% said it did, 31% said it did not, and 21% had no opinion.

There were several possible problems with the study that may have affected the outcomes and its reproducibility. First, when the test items were categorized into knowledge/recall versus integration, was the categorization correct? The questions were divided by one individual into the categories of knowledge/recall and integration. In order to ascertain if the questions were correctly categorized, another individual should have repeated the division. However, this was not possible because the second person would have had to attend all lectures from the

beginning to know if the information in the questions were imparted as knowledge or whether the information was related in a way that integrated it for them. Second, the study may have achieved both objectives but the test instruments may not have been appropriate outcome measures, although the instruments did show a statistical improvement in the case-based group that does reflect improved retention and integration because the examinations were cumulative. Another outcome measure that might have shown a statistical and practical difference between the two groups would have been to give each group a follow-up test when they were in their 5th trimester of school to see how well each retained the information. There is some debate as to the short- and long-term efficacy of utilizing case-based teaching. Martensen and colleagues demonstrated that students in a problem-based course showed no difference in short-term recall but a significant advantage in long-term recall, amounting to 60% higher scores for the problem-based instruction after a period of 2–4 1/2 years (18). A study at Southern Illinois University School of Medicine compared 1st-year medical students who were in either a predominately lecture-based curriculum or a problem-based curriculum. They found no appreciable differences in initial test scores, but on a follow-up retention test given 12 weeks later, the problem-based group scored significantly higher than the lecture group (19). A study at Bowman Gray School of Medicine on the performance of medical students in lecture-based curricula and problem-based (PB) curricula showed no difference in the medical boards. However, the PB students scored higher on rating scales in their knowledge, history taking and examination skills, and their ability to differentially diagnose than the students in the lecture-based curricula (20). Although I did not use a true PB format, a follow-up study should be performed that compares the performance between the spring 2000 control group and the fall 2000 experimental group in clinical problem-solving skills during their internship. A rating scale could be developed that evaluates problem-solving skills, long-term retention, and differential thinking of the students. This information would look at long-term outcomes of case-based learning. The results of this study may enhance the validity of teaching with cases. A third problem was that the survey was not given to the control group. At the time, it did not seem applicable, but after the study it would have been interesting to see how the students who had the traditional lectures would have responded to the questions. Another possible problem is that the test items could be compromised (i.e., students from the control group remembered and therefore provided students in the experimental group with questions and answers) and this might account for the differences in the results between the two groups. This could have been a question placed on the survey.

CONCLUSION

The results supported the hypothesis that the students' ability to integrate information would improve. However, results did not support the hypothesis that their ability to retain basic knowledge would improve. A follow-up study (i.e., retention test) between the two groups would be necessary to show if a significant difference exists in their long-term ability to retain knowledge and integrate information. A satisfaction survey indicated that the students preferred teaching with cases to traditional lectures.

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