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PEER INSTRUCTION IMPROVES PERFORMANCE ON QUIZZES

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Peer instruction is a cooperative-learning technique that promotes critical thinking, problem solving, and decision-making skills. Benson's think-pair-share and Mazur's peer-instruction techniques are simple cooperative exercises that promote student's participation in class and increase student's interaction with each other and with the instructor in a large classroom. We borrowed concepts from Benson and Mazur and applied these concepts to enhance student involvement during the respiratory component of the medical physiology class. The medical physiology class consisted of 256 first-year medical students. The peer-instruction technique was used for 10 classes. Each class of 50 min was divided into three or four short presentations of 12–20 min. Each presentation was followed by a one-question, multiple-choice quiz on the subject discussed. Questions ranged from simple recall to those testing complex intellectual activities. Students were given 1 min to think and to record their first answer. Subsequently, students were allowed 1 min to discuss their answers with their classmates and possibly correct their first response. The percentage of correct answers increased significantly ($P < 0.05$) after discussion for both recall and intellectual questions. These data demonstrate that pausing three to four times during a 50-min class to allow discussion of concepts enhanced the students level of understanding and ability to synthesize and integrate material.

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Key words: active learning; cooperative learning

Learning is not a spectator sport. Students do not learn by simply sitting in a classroom listening to the teacher, memorizing prepackaged assignments, and spitting out answers. Students must talk about what they are learning, write about it, relate it to past experiences, and apply it to their daily lives (4). Students who are actively involved in learning retain information longer than when they are passive recipients of instructions (5). Furthermore, students prefer active-learning strategies to the traditional lecture, and active-learning strategies are equivalent to lecture in promoting content mastery but superior to lecture in encouraging student thinking and writing skills (2). Active involvement enhances the student's level of understanding and ability to integrate and synthesize

material. Active involvement also improves the student's conceptualization of systems and how they function and increases the student's level of retention. (6, 9)

It has been reported that student concentration in a lecture class "rose sharply to reach the maximum in 10 (to) 15 min and fell steadily thereafter" (15). In support of this concept, McLeish documented that students retained ~41% of the content presented during the first 15 min of class, only 25% in a 30-min period, and only 20% during a 45-min period (10). These data document that lengthy lectures are not effective in transmitting information or in promoting retention. To address this concern, Rowe modified

lectures by pausing at least three times during a 50-min class to allow discussion among students. This modification put the focus on clarifying and assimilating the information presented and was effective in promoting learning (12). Similarly, students hearing lectures in which the instructor paused to allow discussion performed significantly better on free-recall quizzes and comprehensive tests (13). Studies have shown that combining segments of lecture with short activities is an excellent way to keep students interested and involved (3). Improved levels of interest and attention increase learning. Thus giving up a few minutes of lecture time for an active-learning activity can actually increase the amount of information covered and retained.

Benson's think-pair-share and Mazur's peer-instruction methods are active-learning activities that are successfully used in large classes (3). Think-pair-share is a simple cooperative-learning exercise. Two to three times during a lecture the instructor asks a question or poses a problem. Students spend a minute or two alone thinking about an answer or solution (think). Subsequently students pair up (pair) to discuss their answers with each other (share) (3). Mazur used a very similar approach. Two to three times during a lecture students solve a physics problem, mark down their answer, and rate how confident they feel about the correctness of their answer. For the pair phase, Mazur allows students 1 min to convince their neighbor of their answer. After students have discussed the problem with classmates, they may revise the answer and again rate their confidence in their second answer. There was a dramatic increase in the confidence level and percentage of correct answers after students discussed the concepts (8). These results documented the importance of encouraging discussion of concepts presented during the class.

We borrowed concepts of Benson and Mazur's peer-instruction activities to promote student's involvement in the learning process. Specifically, classes consisted of three to four short presentations on key points. Each short presentation was followed by a one-question, multiple-choice quiz. The questions on the quizzes ranged from simple recall to comprehensive questions. The students were allowed 1 min to formulate the answer. Subsequently, the students

were allowed 1 min to discuss their answers with their neighbors. This process encouraged critical-thinking, problem-solving, and decision-making skills as well as providing a way to assess the level of understanding. Students were also asked to record their answer to each question after the discussion. We analyzed these responses to determine the effectiveness of this peer-instruction, active-learning approach.

METHODS

Design

This peer-instruction, active-learning technique was implemented during the respiratory component of the medical physiology class. The class consisted of 256 first-year medical students. The peer-instruction technique was used for 10 classes. Each class of 50 min was divided into three to four short presentations of 12–20 min each. Each presentation was followed by a one-question, multiple-choice quiz on the subject discussed. Students were allowed 1 min to think and to record their answers. Subsequently, students were allowed 1 min to discuss their answers with classmates. Students were then allowed to change their first answer if desired, and both answers were collected. Students were not required to identify themselves. We felt that we would obtain responses from all students if they were not required to identify themselves. Students often hesitate to reveal their identity and do not participate actively when their identity is requested. Finally, the instructor and students discussed the answer.

Framing the Questions

One multiple-choice question, of single-best response type, was prepared for each short presentation. Bloom's taxonomy of cognitive domain was used to frame our questions. Bloom classified the cognitive domain into two major groups: 1) simple recall of information and 2) intellectual activities. Bloom labeled the lowest domain as knowledge, whereas the higher order was classified into five levels consisting of comprehension, application, analysis, synthesis, and evaluation (1). We modified Bloom's classification and categorized the questions into three levels. *Level 1* consisted of simple recall questions to test the student's ability to recall information. *Level 2* ques-

tions tested intellectual skills. *Level 3* questions tested synthesis and evaluation skills. It is important to note that the framing of the questions must be put in the context of the peer-instruction format. That is, students were required to answer the questions immediately after exposure to the topic. Thus there was no time to review books or other sources. An example of a *level 1* (recall) question used during the presentation is presented below.

Charles' law states:

A. In a constant-temperature system, pressure is inversely proportional to volume.

B. In a constant-volume system, pressure is directly proportional to the temperature.

C. In a constant-temperature system, pressure is directly proportional to volume.

D. In a constant-volume system, pressure is inversely proportional to the temperature.

Level 2 questions tested intellectual skills. These questions assessed the student's comprehension, application, and analytical abilities. An example of a *level 2* question testing the application domain (application of a rule or principle) is presented below.

A lack of normal surfactant results in. . .?

A. an increased lung compliance

B. stabilization of alveolar volume

C. an increased retroactive force of the lungs

D. a reduced alveolar-arterial oxygen tension difference

E. a decrease in the filtration forces in the pulmonary capillary.

Level 3 questions tested synthesis and evaluation skills. An example of a question involving higher order intellectual activity testing synthesis skills (puts the parts together to make a new whole) is presented below.

A patient is being artificially ventilated during surgery at a rate of 20 breaths/min and a tidal volume of 250 ml/breath. Assuming a normal anatomical dead space of 150 ml, the alveolar ventilation in this patient is

A. 1,000 ml

B. 2,000 ml

C. 3,000 ml

D. 4,000 ml

E. 5,000 ml

Evaluation of the Answers

The students answered a total of 35 single-best type multiple-choice questions during 10 classes. The student's response to each question before and after the discussion was collected, and the mean percentage of correct answers \pm SE for each level was calculated. A Student's paired *t*-test was used to compare the student's answers before and after the discussion.

RESULTS

Figure 1A presents the percentage of correct answers to the *level 1*-recall questions before and after the discussion. Before the discussion, $94.3 \pm 1.8\%$ of the answers were correct. The percentage of correct answers increased to $99.4 \pm 0.4\%$ ($P < 0.05$) after the discussion. Similar results were obtained for *level 2* questions testing comprehensive, application, and analytic skill. Before the discussion, $82.5 \pm 6.0\%$ of the answers were correct. The percentage of correct answers increased to $99.1 \pm 0.9\%$ after the discussion ($P < 0.05$; Fig. 1B). Similar results were also obtained for *level 3* questions testing synthesis and evaluation skills. The percentage of correct answers before the discussion was $73.1 \pm 11.6\%$. After the discussion, the percentage of correct answers increased ($P < 0.05$) to $99.8 \pm 0.24\%$ (Fig. 1C).

DISCUSSION

In this study, we examined the effectiveness of peer instruction, a pedagogical method that promotes student's participation in class and increases student interaction with each other and with the instructor,

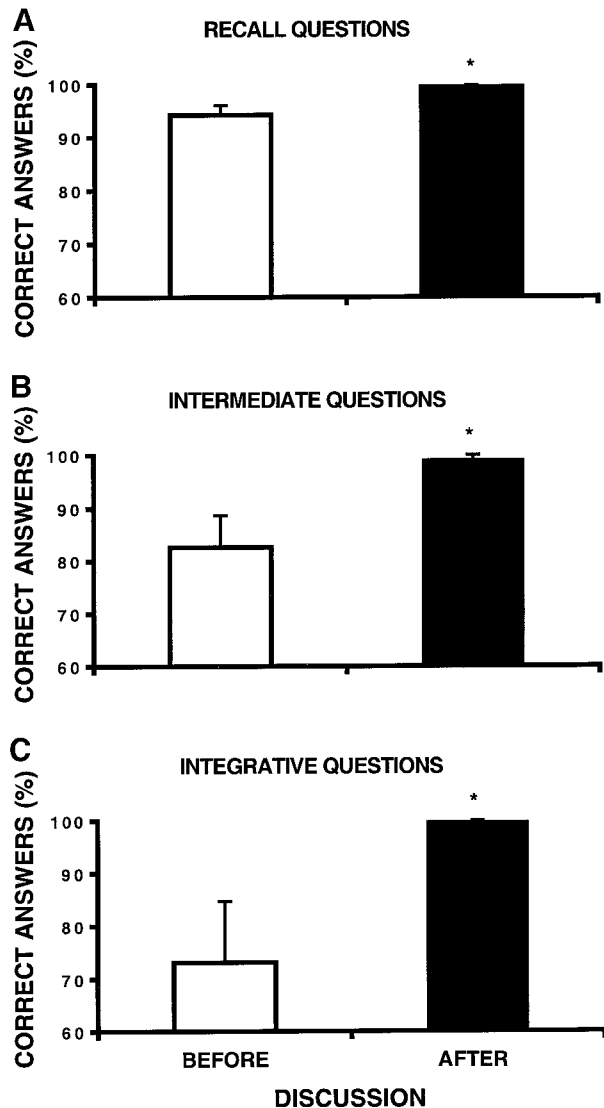


FIG. 1.

A: the percentage of correct answers to *level 1* recall questions before and after the discussion. Before the discussion, 94% of the answers were correct. The percentage of correct answers increased to 99% ($*P < 0.05$) after the discussion. Similar results were obtained for *level 2* questions testing comprehensive, application, and analytical skills. Before the discussion, 82% of the answers were correct. After the discussion, the percentage of correct answers increased to 99% ($*P < 0.05$; **B**). Similar results were also obtained for the *level 3* questions testing synthesis and evaluation skills. The percentage of correct answers before the discussion was 73%. After the discussion, the percentage of correct answers increased ($*P < 0.05$) to 99% (**C**).

on student's performance on quizzes. The major finding is that students perform significantly better on multiple-choice questions after discussion with classmates. Furthermore, the performance on higher-level intellectual questions is increased to a greater extent than the performance on simple recall questions. The initial percentage of correct answers for simple recall questions was ~94%. In this situation, there was little room for improvement. However, the initial percentage of correct answers for higher-level intellectual questions was 73%. In this situation, there was significant room for discussion-induced improvement.

Cooperative peer-instruction activities are active-learning approaches that enhance performance. The performance-enhancing effect of peer instruction may be explained by Silberman (14). Silberman suggested that active learning is effective for the following reasons: "What I hear, I forget. What I hear and see, I remember a little. What I hear, see, and ask questions about or discuss with someone else I begin to understand. What I hear, see, discuss, and do, I acquire knowledge and skill. What I teach to another, I master." The result from the current study supports this active-learning credo. Specifically, when students discussed concepts and taught classmates, their performance on quizzes increased.

By actively involving students in peer-instruction activities, the student's attention span may be greatly increased. It has been reported that students in a lecture-based college classroom are not attentive ~40% of the time (11). During sustained lectures, student attention decreases with each passing minute. Furthermore, sustained lectures appeal only to auditory learners and tend to promote lower-level learning of factual information. Finally, sustained lecturing assumes that all students learn the same information at the same pace (7). Thus incorporating peer-instruction, active-learning activities may increase student's attention and appeal to a greater number of learners (e.g., visual, tactile, auditory, etc.).

In this study, each 50-min class was organized into three to four presentations of 12–20 min. In this situation, student attention may have been enhanced. This increased attention may explain the high percentage of correct answers (94% for recall questions and 73% for higher-level intellectual questions) even

before the discussion. However, even in this situation, discussion facilitated an understanding of the material that was reflected in the improved performance on the quizzes. Ruhl and colleagues (13) also reported increased performance on quizzes when the instructor paused for 2 min on three separate occasions during a lecture to allow discussion. Thus students hearing lectures in which the instructor paused did significantly better on the free-recall quizzes and comprehensive tests.

Student's ability to solve problems is enhanced by discussion (2). Interestingly, in this study, there was always an increase and never a decrease in the percentage of correct answers after the discussion. Mazur postulated that it is much easier to change the mind of someone who is wrong than it is to change the mind of someone who has selected correct answers for the right reasons (8). Thus incorporating peer discussion always improves student's performance on quizzes.

Faculty are often reluctant to incorporate active learning activities in the class. The reasons most often advanced for not including these active-learning activities include not being able to cover as much content in the time available, excessive preparation time required for devising strategies promoting active learning, and not being able to implement active strategies in large classrooms (2). However, results from this study suggest that peer instruction enhances the quantity, depth, and detail of material covered. In terms of preparation time, minimal extra time is required for this active approach. Furthermore, the minimal extra time pays dividends in understanding and retention of material. Finally, this study also suggests that peer instruction is an effective active-learning strategy that can be easily incorporated in large classrooms. Pausing for a few minutes at 12- to 20-min intervals allows discussion and reduces the unavoidable monotony of passive learning. Discussion also encourages analysis and synthesis of concepts as well as sharing of knowledge with classmates. As stated by Mazur, using time for peer instruction greatly improves student's level of understanding with relatively little effort and no capital investment (8).

Results from this study suggest that pausing three to four times during a 50-min class to allow peer instruction of

concepts enhanced the student's level of understanding and ability to synthesize and integrate material. It is possible to create an effective active-learning environment in a large classroom with relatively little effort by implementing peer-instruction technique.

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