A prospective, controlled, blinded study assessing the effectiveness of inquiry-based Mini-Case Study exercise in learning topics of high importance in Human Physiology

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Abstract

The Association of American Colleges and Universities (AACU) state that student centered learning processes are a high-impact teaching practice. These processes help students develop critical thinking skills and reflective judgment and they foster group collaboration, which improves the learning process. The purpose of this study was to assess the effectiveness of a mini-case study exercise as a supplement to learning five topics of high importance in Human Physiology. Students in the sections that performed mini-case study exercises had higher grades on questions that pertained to these topics than those who did not perform the mini-case studies. Adding a mini-case exercise to the curriculum made a substantial improvement in student understanding of the subject matter and the grades they achieved on questions pertaining to topics in Human Physiology.

Introduction

The Association of American Colleges and Universities (AACU) advocate student centered learning processes in the classroom, believing them to be a high-impact teaching practice. Student centered learning processes promote student collaboration, group interaction, appreciation of multiple perspectives, reflective judgment, critical thinking skills, and enhanced understanding of a topic (AACU 2007).

Case studies are one type of student centered learning process. A case study is an inquiry-based technique that follows the scientific method approach to solving a problem. In a case study exercise, students are provided with results based on a scenario (real-life or fictional) that pertains to a topic taught in class. Students are then asked to answer questions related to the case study by working backwards using information in the textbook, laboratory manual, lecture or other references. This progression is in essence the introduction, concepts, and methods of the scientific method. A mini-case study is a short descriptive scenario consisting of a paragraph or two of written material (Herreid 2007, Shmaefsky 2007, Herreid 1994, Herreid 2004, Yadav *et al*. 2007, Nobitt *et al*. 2010).

Purpose

The purpose of this study was to assess the effectiveness of a mini-case study exercise as a supplement in learning topics of high importance in Human Physiology and in promoting group activity, developing student participation and collaboration, and developing critical thinking skills and sound judgment.

Methods

The study was conducted in the Fall semester 2013. Two day sections and one night section of Human Physiology, a total of sixty-eight Freshmen and Sophomore level students, were evaluated. This was a prospective blinded cross-over study that was approved by the Monroe Community College Investigational Review Board. Strict confidentiality of student information was adhered to.

The purpose of this study was to assess the effectiveness of Mini-Case Study Exercise as a supplement in learning five important topics in Human Physiology: homeostasis, membrane transport and urinary system physiology, scientific method and skeletal muscle physiology. The participating day and night sections were divided into two arms. Arm A comprised the one evening section and Arm B the two day sections. Students in Arm A performed Mini-Case Study Exercises on Homeostasis, Membrane Transport, and Urinary System Physiology; students in Arm B performed Mini-Case-Study Exercises on the Scientific Method and Skeletal Muscle Physiology. This design alternates the experimental and control between day and evening sections based on whether the section was performing an exercise on a particular topic. The design focuses on the effectiveness of the exercise while controlling for any possible difference in quality of student in day or evening sections. The case study exercises were an additional supplement to lecture and laboratory information on these study topics. Students in all sections received the same information about a study topic using standard lecture and laboratory methodology. Students in the day and evening sections did not interact which could have confounded the results.

Design Scheme:

All students in the day and evening sections received information on the five study topics using standard teaching lecture and lab methods (a typical didactic teaching approach).

Arm A (Evening Section)
Performed Case-Study Exercises on Homeostasis, Membrane Transport, and Urinary System

Arm B (Two Day Sections)
Performed Case-Study Exercises on Scientific Method and Skeletal Muscle

Those who received Case-Study Exercises were the experimental group and those who did not were the control
(Students in Arm A could be an experimental group in one situation and a control in another and the same for students in Arm B)

Assessment

Compared whether receiving a Case-Study Exercise on a particular topic had any effect on student performance on test questions dealing with that topic.

Case study exercises and instructions were presented to students by the professor in the Human Physiology laboratory. A hard copy of the case study assignment was given to each student. It consisted of a case study scenario pertaining to one of the five topics (homeostasis, membrane transport, urinary system physiology, the scientific method, and skeletal muscle physiology) and one assigned question pertaining to the scenario. Students were placed in groups of four and given roles/duties as follows:

1) an **umpire** who kept the group focused and maintained civility
2) a **recorde**r who took detailed minutes
3) **a detective and an interpreter** who summarized discussions, asked questions, and generated suggestions and ideas (Brookfield 2012).

The following are examples of two of our mini-case study exercises. The first one involves homeostasis:

Katie is working in the garden. The air temperature is 97^0 F and the humidity is high. She is sweating profusely and after an hour feels dizzy and faint. Her daughter, Susan, an RN, notices her mother's disorientation and leads her into a shaded area. She takes her mom's blood pressure and it is low. She takes her mom's pulse and it is slightly elevated. Susan gives her mom a couple of cold glasses of water and in a while her mom feels more alert. Katie's blood pressure and pulse return to normal and she no longer feels faint or disoriented.

The assigned question related to this mini-case study is: Sweating is a good way to cool down, but what is the negative consequence of excess sweating?

The second mini-case study example involves membrane transport:

Baby Julie has just been diagnosed with a congenital disorder. The brush border cells (simple columnar with microvilli) of her small intestine have non-functional glucose/galactose symporters. Baby Julie is losing weight while breast feeding or receiving infant formula. She also has diarrhea and she is dehydrated.

The assigned question related to this mini-case study is: Why does baby Julie have diarrhea?

Each group was asked to describe the significance of the case study, explain how it related to a topic and answer the assigned question that was associated with their case study. Students were encouraged to contribute thoughts, ask creative questions, prod each other to action, and use suggestions as rungs on a ladder, to lift individual students and the group as a whole to a better understanding of the topic. During this period of group interaction, the instructor acted as a facilitator. The time allotted for this activity was approximately 30-45 minutes to complete the first part of the case study exercise.

Each student in the group was required to develop an additional unique and substantiated question related to the case study. This assignment was worth 30 points. Students were given one week to complete the assignment. Students were encouraged to confer with other group members during the week using the Blackboard Course Management System discussion board. During laboratory the following week, each

group chose one of the four questions developed by a colleague to be presented to the class. One individual from each group presented this question to the class. The presenting student was required to discuss the answer to their question, provide supporting evidence for their answer and to explain the relevance of their question to the case study. The class asked questions and discussed the presentation as it related to the case study topic. The time allotted for this activity was approximately 30-45 minutes.

Methods Assessment

The effectiveness of the Mini-Case Study exercise as a learning tool was assessed by comparing the percentage of students in the two different groups who correctly answered multiple-choice and short-answer questions on lecture exams that covered the information found in their case study.

Project assignments were graded assessing:

1) the general knowledge that students evidenced about their topic
2) evidence of critical thinking in student explanations
3) the manner in which the students arrived at their conclusions
4) the caliber of the evidence and arguments with which students supported their conclusions

A rubric was used to assess critical thinking on six categories. A grading scale from 1 to 6 was given based on the level of proficiency in a category. The levels were Emerging (1-2), Developing (3-4) and Mastering (5-6). The categories were:

1) student summation of the problem, question or issue
2) clarity of student expression of their own perspective
3) evidence that students were able to formulate an acceptable hypothesis
4) student analyses of their supporting data and evidence
5) student appreciation of the perspectives and positions of others
6) student ability to reach a satisfactory conclusion and communicate the implications and consequences of that conclusion

Students assessed the efficacy of the case study exercise methodology after each session using a Likert scale and open-ended question. The open-ended question was: What are the strengths and weaknesses of using a case study learning approach? Students self-assessed their development and progress in this learning method using a Likert scale and an open-ended questionnaire.

Group dynamics as a learning method was also evaluated. Notes were taken by the recorder of each group and discussions were evaluated looking at commonality or differences of thought and approach within and among groups including these key points:

1) Did every student in the group contribute to the discussion?
2) Were multiple view-points expressed within the group?
3) Was civility maintained within the group?
4) How did the group decide on an answer to the questions?

5) Were arguments defended with sound logic and proof?
6) Were members of the group able to build a consensus?

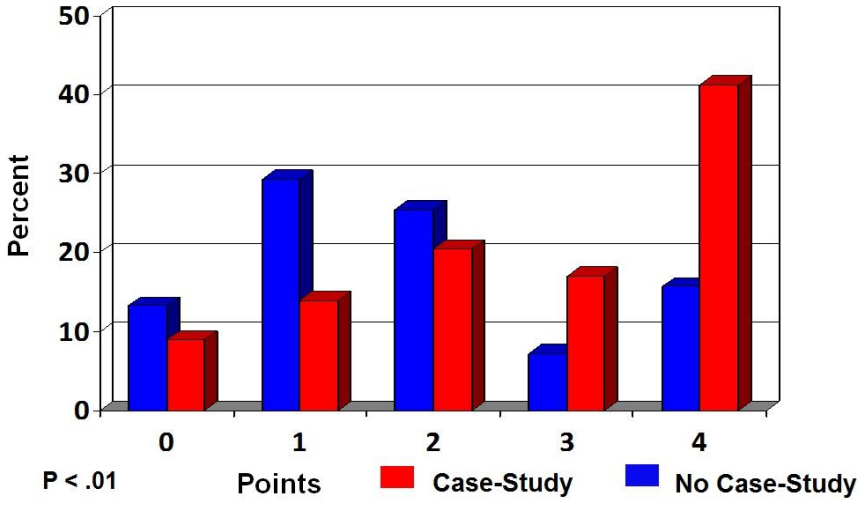
Statistical Analysis

Qualitative data such as the results from a questionnaire or assessment of the Case Study exercise methodology were expressed using graphs. Raw data from exams and assignments evaluating the difference in scores achieved by students in the different arms were compared statistically using Chi-square in Microsoft Excel.

Results

Students who performed case study exercises had similar results on Exam I multiple choice questions, related to the case study topic, as those students who did not receive the exercise $P > .05$. Students who performed case study exercises did better on multiple-choice questions pertaining to the case study topics on Exams II, III and IV than students who did not receive these exercises. Some of the differences were statistically different $P < .05$. Graph 1 combines the results of five different short answer questions on four different exams. Each short answer question was worth 0 to 4 points. Students who did the case study exercises received higher grades on short answer questions than those who did not receive this additional learning exercise $P < .05$.

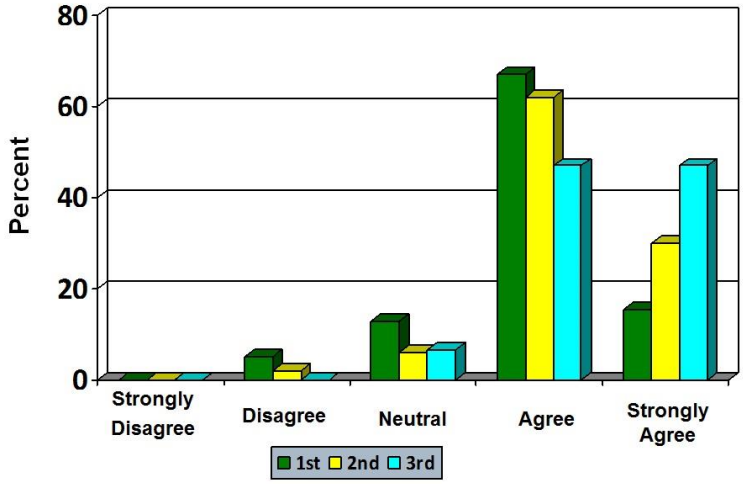
Graph 1 Results on short answer questions were compared between students who received case study exercises and those who did not. The graph compares the average percent of students from the two groups who received 0 to 4 points on five different short answer questions on four different exams.



The numbers of students who agreed that the use of case study exercises is an effective method of teaching and learning increased after each experience with this learning method (Graph 2). The responses by day and evening students to the open-ended question concerning the strength of this learning method were similar.

Students felt case study exercises reinforced education and knowledge of a topic, provided a practical application of topic, promoted group interaction such that students learned from of each other, taught research skills, fostered critical thinking skills and fostered an appreciation for different perspectives.

Graph II Comparison of student opinions concerning the efficacy of case study exercise as a method of learning, after the 1st, 2nd and 3rd exercises.



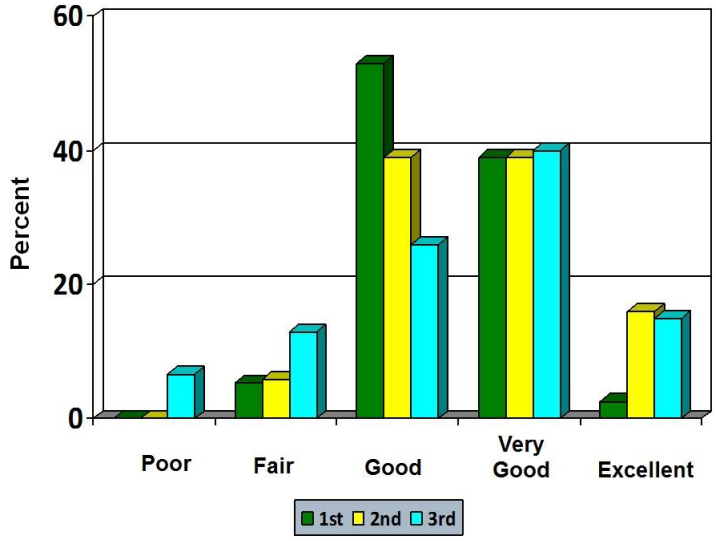
Students generally agreed that the use of mini-case studies required:

1) adequate preparation and time to perform the exercise
2) clearly stated directions and definitions
3) timely advisement and counseling of groups by the facilitator (instructor) and adjustment within groups when necessary to insure proper group dynamics
4) on-going, facilitator-led teaching of research techniques including assistance with finding appropriate references and providing encouragement in learning to think critically

Students improved with experience in each critical thinking category and by the third exercise most students fell within the developmental level 3-4 with a few students scoring even higher.

Students agreed that their skills in tackling case study assignments improved after each experience with this learning method (Graph 3).

Graph III A comparison of student self-assessment of their skills in the case study process after the 1st, 2nd and 3rd exercises.



Conclusion/Discussion

Students who performed case study exercises received significantly higher grades on short answer questions than those who did not receive this method of learning. Students who received case study exercises appeared to have a more comprehensive understanding of the topic. They were better able to interpret, integrate and apply information pertaining to the topic. The Mini-Case process facilitates a deeper understanding of the topics.

Students improved in their approach to this process after each exercise/assignment. Students agreed that the case study method of learning was effective. It encouraged critical thinking, reinforced their understanding of a topic and provided a practical application for the information. Group interaction allowed students to collaborate, gain wider insight into the topic, and learn new material from different perspectives.

There was a learning curve for the effective use of min-case studies for both students and the instructor. Initially students found this process new and confusing. It was not until the second case study exercise that students began to feel more comfortable with the process and gain the confidence they needed to manage the process successfully. This greater level of comfort and confidence was reflected in their grades and attitudes. The role of the instructor is predominantly to act as a facilitator in the process. The instructor/facilitator should be prepared to handle unexpected challenges as they arise, especially at the start of the process. It is very important for the instructor/facilitator to do the following:

1) Provide clear instructions for the students.
2) Set aside adequate class time for the preparation and completion of the mini-case study exercises.
3) Provide adequate group advising to ensure that the work load is shared equally among all of the students in each group and that the group dynamics remain favorable.
4) Provide ongoing supervision and help to ensure that students are able to find appropriate research materials and practice critical thinking skills.

The use of Mini-Case Study exercise as a supplement to instruction of topics of high importance in Human Physiology is an effective and fulfilling activity for both the instructor and the students.

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