A Prospective, Controlled, Blinded Study Assessing the Effectiveness of a Student Centered Exercise in Learning Topics of High Importance in Human Physiology
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A prospective, Controlled, Blinded Study Assessing the Effectiveness of a Student Centered Exercise in Learning Topics of High Importance in Human Physiology

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Abstract
The Association of American Colleges and Universities (AACU) states 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 student centered exercise that included a mini case study as a supplement to learning five topics of high importance in Human Physiology. Students in the sections that performed the student centered exercises had higher grades on questions that pertained to these topics than those who did not have access to the exercise. The author found that adding a student centered 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) advocates student centered learning processes in the classroom, believing them to be a high-impact teaching practice. 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. Additional student centered teaching techniques can be added to a case study to enhance the learning process. These techniques are designed to foster student collaboration, group interaction, peer review, problem solving, assessment of multiple perspectives, reflective judgment, and critical thinking. (AACU 2007, Brookfield 2012, Crumly 2014, Felder and Brent 2009, Herreid 1994, Herreid 2004, Herreid 2007, Nobitt et al. 2010, Shmaefsky 2007, Weimer 2002, Yadav et al. 2007).

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Methods
The study was conducted in the Fall semester 2013. This was a prospective blinded cross-over study that was approved by the Monroe Community College Investigational Review Board. The exempt protocol summary form, listing the responsibilities of the principal investigator, was signed by the IRB Committee Chair on July 15, 2013. No IRB number was assigned to this study. Strict confidentiality of student information was adhered to.

The purpose of this study was to assess the effectiveness of a student centered exercise as a supplement in learning five important topics in Human Physiology: homeostasis, membrane transport, urinary system physiology, scientific method and skeletal muscle physiology. Two daytime sections and one night section of Human Physiology, a total of sixty-eight freshmen and sophomore level students were evaluated.

The participating day and night sections were divided into two arms. Arm A comprised one evening section, a total of 24 students, and Arm B comprised the two daytime sections, a total of 44 students. Students in Arm A performed three student centered exercises on Homeostasis, Membrane Transport, and Urinary System Physiology. Students in Arm B performed two student centered exercises on the Scientific Method and Skeletal Muscle Physiology.

This design alternated the experimental and control between day and evening sections based on whether the section was performing an exercise on a particular topic. The design focused on the effectiveness of the exercises while controlling for any possible difference in quality of...
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 a student centered exercise on homeostasis membrane transport and the urinary system

Arm B (Two Day Sections) performed a student centered exercise on scientific method and skeletal muscle

Those who received a student centered exercise were the experimental group and those who did not served as 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 student centered exercise on a particular topic had any effect on student performance on test questions related to that topic.

A mini case study student centered exercise and instructions were presented to students by the professor in the Human Physiology laboratory. A hard copy of the exercise 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 an assigned question pertaining to the scenario. Students were placed in groups of four and given roles/duties as follows (Brookfield 2012):

1) an umpire who kept the group focused and maintained civility
2) a recorder 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° 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: Why does baby Julie have diarrhea?

Each group was asked to describe the significance of the 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 student centered 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 student centered 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 student centered learning approach?

Students self-assessed their development and progress in this learning method using a Likert scale and an open-ended questionnaire.

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 student centered exercises received higher grades on short answer questions than those who did not receive this additional learning exercise P < 0.05.

Statistical Analysis
Qualitative data such as the results from a questionnaire or assessment of the student centered 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 and Microsoft Excel.

Results
Students who performed student centered 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 > 0.05.

Students who performed student centered 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 < 0.05.

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 number of students who agreed that the use of a student centered exercise 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 the exercise reinforced learning and understanding of a topic, provided a practical application for the topic, promoted collaborative learning, taught research and critical thinking skills and fostered an appreciation for different perspectives.

Students generally agreed that the use of a student centered exercise 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 ensure proper group dynamics
4) on-going, facilitator-led teaching of research techniques including assistance with finding appropriate references and encouraging students 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 study assignments improved after each experience with this learning method (Graph 3).

**Conclusion/Discussion**

Students who performed a student centered exercise received significantly higher grades on short answer questions pertaining to the study topics than those who did not receive this method of learning. Students who received the study exercises appeared to have a more comprehensive understanding of the study topic. They were better able to interpret, integrate and apply information pertaining to the topic. These results support the literature (AACU 2007, Brookfield 2012, Bullard et al. 2008, Crumly 2014, Felder and Brent 2009, Herreid 2007, Weimer 2002).

Students improved in their approach to this process after each exercise/assignment. Students agreed that the student centered 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. This data affirms the positive impact student engagement has on learning as put forth by other authors (AACU 2007, Brookfield 2012, Felder and Brent 2009, Herreid 2007).

The author believes that there was a learning curve for the effective use of student centered learning for both students and the instructor. Initially students found this process new and confusing. It was not until the second 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 continued on next page
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 study exercises.
3) Provide adequate group oversight 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.

Brookfield (2012) is a proponent of student assessment of a course. This allows for student input concerning appropriate changes to class activities. The author found student assessment helpful as a tool to refine group dynamics, student engagement and student learning. The author believes that the use of a student centered 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. Student centered learning has been encouraged and shown to be effective by the AACU and others. Human physiology faculty are often aware of the significance of this technique but they may feel strapped for time to initiate a student centered methodology or they may not know how to approach a student centered process. The author encourages human physiology faculty to try this method. The student centered learning activity presented in this article is easy to implement. It is an activity that progresses quickly, makes efficient use of class time, and has been validated through a controlled experimentation.

References cited


About the Author

James Cronmiller is an Assistant Professor of Biology at Monroe Community College in Rochester, New York where he teaches Human Anatomy and Physiology. James is the Co-Director of undergraduate research at MCC and he is the chairperson of the Institutional Review Board (IRB) at the college and at Rochester General Hospital.

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