Use of critical interactive thinking exercises in teaching reproductive physiology to undergraduate students

M. W. Peters*, M. F. Smith†, and G. W. Smith*†

*Department of Animal Science, Michigan State University, East Lansing 48824-1225 and †Department of Animal Science, University of Missouri-Columbia, Columbia 65211

ABSTRACT: In higher education, increasing emphasis is being placed on the use of new technologies in the classroom. However, the emphasis needs to be placed on methods that truly enhance understanding and knowledge retention. Class discussions help students understand and retain information previously presented in lecture format. Furthermore, if students are challenged to critically evaluate, communicate, and defend their ideas, knowledge retention and understanding will increase even more. Critical interactive thinking exercises (CITE) were employed at two different universities to enhance student knowledge retention and promote the development of critical thinking. Applicability of CITE to undergraduate learning was assessed over a 3-yr period in the undergraduate reproductive physiology courses at Michigan State University and the University of Missouri-Columbia. For each exercise, students were challenged to prepare a one-page, double-spaced composition addressing an incompletely understood phenomenon or problem-solving situation related to the reproductive system. In preparing their compositions, students were encouraged to use information previously presented in lecture plus outside information to develop their ideas. Students were required to formulate and defend a hypothesis or approach to the problem presented. At the subsequent class period, students were divided into groups of three to four, in which they interactively discussed their ideas. Each group member was challenged to defend his or her hypothesis and explanation and to persuade other group members to adopt their ideas. Each group then arrived at a consensual opinion that was presented during a discussion by the entire class. The class then debated the merits of each group's hypothesis or explanation and the supporting arguments presented. At first, the students were apprehensive about the CITE, particularly about communicating and defending ideas with their classmates. However, course evaluations showed that 131 out of 137 students considered the CITE a positive experience that enhanced learning. Additionally, 131 out of 137 students reported that the CITE enhanced their critical thinking skills. We feel that the use of CITE in teaching reproductive theory to undergraduate students fosters critical thinking skills, communication skills, and knowledge retention. The general concept can be readily applied to courses in other subject areas in the animal sciences.

Key Words: Reproduction, Teaching

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Introduction

Teaching students to critically analyze information is a common goal among undergraduate educators (Kurfiss, 1988; Nelson, 1994). Studies indicate that class discussions help students understand and retain approximately 50% of the information previously presented in lectures (Spady, 1991). In addition, development of critical thinking skills will concurrently aid student retention and understanding of fundamental information presented in lecture format (Spady, 1991). To begin using critical thinking skills, students must not only resort to recalling discrete facts, but must also look for ways to apply and integrate discrete facts to support their viewpoints. Class discussions are an effective method of increasing students' knowledge retention and understanding while fostering critical thinking skills. In this article, we discuss a novel approach, known as critical interactive thinking exercises (CITE) that we have applied to help foster knowledge retention and critical thinking skills in undergraduate reproductive physiology students. The CITE were developed and applied to undergraduate education in reproductive physiology based on an exercise developed by Nelson (Nelson, 1997) and presented at a national teaching symposium at the 1997 American Society of Animal
Science meetings. In the CITE, students review and evaluate fundamental concepts and formulate a hypothesis or solution to address an unexplained phenomenon or problem-solving scenario related to reproductive physiology. Students then discuss and critically defend their opinions among their peers, and attempt to persuade classmates to adopt their viewpoint. Based on student evaluations and instructor observations over a 3-yr period, the CITE were judged to be useful for enhancing knowledge retention and critical thinking skills.

**Materials and Methods**

The applicability of CITE was assessed in Animal Science (ANS) 405, Endocrinology of Reproduction, at Michigan State University, and ANS 304, Physiology of Reproduction, at the University of Missouri-Columbia. A total of 137 students participated in the exercises. The data set described here includes 45 students from Michigan State University that were enrolled in ANS 405 in the fall semesters of 1998, 1999, or 2000 and 92 students from University of Missouri-Columbia enrolled in ANS 304 in the winter semesters of 1999 and 2001. Animal Science 405 is a 4-credit course that consists of three lectures and one lab per week, whereas ANS 304 is a 3-credit course that consists of two lectures and one lab per week. Class enrollment consists of students of junior and senior standing. Both classes have a general physiology course as a prerequisite. Class sizes ranged from 15 to 48 students. The exercises were conducted five to six times per semester in place of a lecture or lab period, when they conveniently fit into the course syllabus. No preference was observed for exercises being done in the lecture or lab period. The exercises were also conducted at the University of Missouri-Columbia in 2000, but data were not collected.
Begning of the session. For 20 min, each group member was challenged to defend their position and persuade other group members to adopt their ideas. Students were encouraged to mark on their own papers with red ink if their arguments were changed or modified to align with the viewpoints of others or to denote other points of interest raised by their peers. The small group discussions operated independently, with the course instructors and teaching assistants facilitating only when necessary. Each group then arrived at a consensus theory/solution to explain the scenario at hand. Then, for 25 min, the designated group spokesperson, different for each exercise, presented the groups’ consensus theory or approach during an overall class discussion. Other class members were free to also add input when necessary. Every class member served as group spokesperson at least once during the semester. The entire class debated the merits of each group’s position. The instructors or teaching assistants served as moderators for the whole class discussion and interjected only when necessary to clarify key concepts or reinforce the critical thinking process.

At the end of each discussion period, written compositions, with additions or modifications in red ink, were collected. Instructors provided written feedback to the students within two class periods. Emphasis in feedback was placed primarily on evaluation of and ways to improve critical thinking skills. To ensure equal participation and devotion of maximal effort and intensity to the process, students received a grade for each exercise. Full credit was awarded as long as students demonstrated desired effort on the written component and were engaged participants in the discussion sessions.

The utility of the CITE was determined primarily through analysis of data collected from supplementary student surveys as part of the formal class evaluation process and through instructor’s observations. Students were specifically asked to evaluate whether the CITE questions enhanced overall learning and whether the exercises enhanced their critical thinking skills. General comments were also solicited. Written student responses were evaluated to determine whether individual respondents felt the CITE enhanced their learning and critical thinking skills. Data from the learning responses were separated into two (enhanced or did not enhance) categories. Data from the critical thinking responses were separated into three categories (greatly enhanced, somewhat enhanced, or did not enhance). For each question, the proportion of students responding in each category was analyzed using chi-squared analysis by the Proc Freq function of SAS (SAS Inst. Inc., Cary, NC).

Results and Discussion

Cumulative results of student surveys collected at two institutions (Michigan State University and the University of Missouri-Columbia) over a 3-yr period strongly support the utility of CITE as a tool to enhance undergraduate instruction in reproductive physiology. At final course evaluations, 95.6% (n = 131) of all students surveyed felt that the CITE activity was a positive experience that enhanced their learning (Figure 3, \( P < 0.0001 \)). Additionally, a significant proportion (90.5%, n = 124) of students thought the CITE activity greatly enhanced their critical thinking skills \((P < 0.0001)\). An additional 5.1% (n = 7) rated the CITE activity as an experience that somewhat enhanced their critical thinking skills. A final 4.3% (n = 6) felt the CITE activity did nothing to enhance their critical thinking skills (Figure 4).

The benefits of the CITE were tangible and grew even more evident as courses progressed. At the beginning of the semester, students were apprehensive about use of the CITE in the course. However, having students

![Figure 3](image-url) Percentage of undergraduate students (n = 137) in reproductive physiology courses at Michigan State University and the University of Missouri-Columbia indicating that the critical interactive thinking exercises enhanced or did not enhance their learning and comprehension of course material. \(^{a,b} P < 0.0001\).

![Figure 4](image-url) Percentage of undergraduate students (n = 137) in reproductive physiology courses at Michigan State University and the University of Missouri-Columbia who indicated that the critical interactive thinking exercises activity greatly enhanced, somewhat enhanced, or did not enhance their critical thinking skills. \(^{a,b} P < 0.0001\).
engage in educational conflict among themselves has been reported to enhance student interest in subject matter and motivate them to search for more information (Johnson et al., 2000). After the first discussion session, enthusiasm for the CITE grew as students began to enhance their critical thinking skills. We (course instructors) noted that with subsequent CITE, students developed more complex and thoughtful answers. Students also began to seek the advice and opinions of professionals from outside the class to solidify their arguments. Inevitably, the exercises became a welcome challenge to both instructors and students, and innovative and insightful ideas and approaches emerged that had not been previously considered. Based on general written comments provided by students, it was clear that they appreciated the overall usefulness of the exercises. Students with diverse goals (management of livestock operations or graduate education) clearly recognized the benefits that the development of critical thinking and problem-solving skills would provide later in life. We (instructors) also felt that the CITE enhanced instructor-student dialogue, both during lecture periods and outside of class. In general, students were comfortable and confident asking questions and challenging ideas presented in lecture. Also, the CITE helped promote knowledge retention and greater in-depth understanding of the areas discussed. Open discussion of particular topics allows the instructors to clarify areas of misunderstanding and fill knowledge voids left from the lecture and lab presentations.

We acknowledge that somewhat subjective criteria were used to evaluate the utility of the exercises for development of critical thinking skills. At the minimum, our criteria provide a very strong indication of general utility of the CITE as a tool to encourage students to critically examine the subject matter. Further evaluation of the CITE using established standardized instruments to measure critical thinking skills will be of interest in the future.

Potential pitfalls to using CITE in undergraduate reproductive physiology courses include the loss of lecture time and student apprehension about expectations for the compositions and discussion periods. These drawbacks can be overcome with careful planning and explicit written feedback from the instructor after each exercise. We feel strongly that lost lecture time is more than compensated for through the enhanced retention of information presented in lecture, through facilitation of critical thinking and a deeper level of comprehension, and by providing a stimulus for students to further explore subject matter independently.

**Implications**

Undergraduate educators are continually challenged to find new approaches to enhance student knowledge retention and to foster critical thinking. We found that the use of critical interactive thinking exercises in undergraduate reproductive physiology courses enhanced student comprehension and retention of material and the development of critical thinking skills. The exercises also helped create an environment in which students felt more comfortable asking questions during lectures. We believe the principles of the exercises described for use in undergraduate reproductive physiology courses have general merit and can be applied to other subject areas in the animal sciences. Questions would need to be developed in the area of interest that require the students to think abstractly and develop hypotheses. Regardless of discipline being taught, the critical interactive thinking exercises can be used to foster knowledge retention, communication skills, and the development of critical thinking and problem-solving skills.

**Literature Cited**


