Effectiveness of Elements of a Diversified Instructional Approach in an Introductory Biology Course

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Abstract: Students enrolled in a large-lecture, non-majors biology course employing a diversified instructional approach featuring both instructor-centered and student-centered techniques evaluated the effectiveness of each approach in fostering course goals. Students perceived both approaches to be effective to some extent. Students indicated that the instructor-centered approach was more effective than student-centered instruction in fostering knowledge of biological content and of the nature of science, making the course meaningful, and promoting interest in biology as a discipline. Student-centered instruction was perceived to be more effective in engaging students in the learning process, helping students construct their knowledge, and making the course interesting. Students indicated they preferred a diversified instructional approach, noting that the varied instructional environment helped to keep the classroom atmosphere engaging.

Keywords: instructor-centered, student-centered, active learning, introductory biology

Introduction

Studies have revealed the effectiveness of student-centered, active learning strategies in promoting meaningful learning, retention of content, improved student attitude and the development of critical thinking skills (Klionsky, 1998; Lawson, 2001; Lord, 2001). In response to these findings, calls for reform in science education over the past decade cite the need for college science faculty to diversify their instructional approach by incorporating active learning strategies in their courses (McNeal and d'Avanzo, 1997; NRC, 2003; NSF, 1996; Seymour and Hewitt, 1997; Uno, 1999). Yet the shift from the traditional, passive, instructor-centered paradigm has been a slow one (Adams and Slater, 1998; Anderson, 1997, Rice, 1996). Faculty unfamiliarly with student–centered instructional strategies, a lack of content specific curricular materials, and a lack of time have been identified as barriers to the implementation of a more diverse instructional approach (Laurer, 2003; Sunal, Bland and Sunal, 2001). For faculty to diversify their instructional approach, they must take a more scholarly approach to their instructional choices (Allen and Tanner, 2005; Powell, 2003).

A specific student-centered, active learning strategy that has shown to be effective in college science classrooms is the use of small-group cooperative learning activities (Astin, 1993; Tobin, Capie and Betterncourt, 1998). Such activities can "complement lectures by providing a social context in which a student constructs individual understanding of the content presented in lecture" (Preszler, 2006), and actively engage students in science content. These activities may be particularly effective in large enrollment science courses where students may feel isolated and disengaged in the course (Anderson, 1997; Christensen, 2005; Michaelson, Knight and Fink, 2002; Suchman, Timpson, Linch, Ahermae and Smith, 2001). In response to calls for faculty to evaluate the effectiveness of their attempts to improve science education (Allen and Tanner, 2005), this study documents students' perceptions of the effectiveness of the implementation of a diversified instructional approach in a large enrollment introductory biology course. Findings detailed here may inform efforts to design instruction with the most effective balance of instructor-centered and student-centered approaches.

Middle Tennessee State University offers an introductory biology course specifically designed for non-majors. The course is designed to provide students with the understanding, experiences and skills that foster informed decisions on biological issues that affect their lives. In the course, efforts are made to promote meaningful learning of biological content by making the course relevant and engaging critical thinking skills through both instructor-centered and student-centered approaches. The lecture components of the course are generally large, often over 100 students.

Methods

This study describes a course taught utilizing a diversified instructional approach that combined traditional, instructor-centered lecture/discussion elements along with instructor-designed, student-centered cooperative learning activities. In the instructor-centered approach students participated in lectures and discussions that were supplemented by PowerPoint™ presentations, and answered questions posed by the instructor. In the student-centered approach, students worked in cooperative teams of approximately four students, discussing and formulating group responses to questions concerning issues relevant to the biological content. The cooperative learning activities were structured so that each member of the group acted as the 'discussant' for one of four sets of questions, facilitating discussion and formulating the group's response. For example, when covering the nature of science as a method of inquiry, students assembled into groups of four and were given a description of an advertisement for a herbal product that is promoted as having 'scientific proof' of its effectiveness as a weight loss supplement. Student groups analyzed the scientific validity of the claims by answering four sets of questions regarding the advertisement with each student acting as the discussant for one of the sets of questions (Appendix A). For some of the activities, the students were allowed to self-assemble in groups, while for others, the instructor formed the groups. For each of the topics in the course, both instructor and student-centered approaches were utilized. Overall, the balance of instructional approaches utilized was approximately 75% instructor-centered and 25% student-centered.

To assess students' perceptions of the relative effectiveness of student-centered and instructor-centered approaches utilized in the course, students were administered an end-of-course survey (Appendix B) that was approved by the university's 'Institutional Review Board.' Ninety-four students out of the 120 students completing the course completed the survey. The survey employed a 5-point Likert scale (with 1 indicating strong disagreement, and 5 indicating strong agreement) that students utilized to evaluate the effectiveness of each approach in achieving specific course goals. Students were also asked to indicate the balance of instructional approaches they felt would best achieve course goals, as well as their perceptions of the advantages and disadvantages of each instructional approach. To determine if differences existed in student perceptions of the effectiveness of each approach in achieving course goals, the data were analyzed utilizing Student's t-tests (n = 94).

Results

Each approach was perceived as being effective in promoting course goals with each item achieving a mean response of greater than a '3' on the five point Likert scale utilized, and most students indicating a degree of agreement for each item (Figure 1). The instructor-centered approach was perceived to be most effective in promoting aspects of student knowledge (biology and the nature of science), making the course meaningful and fostering critical thinking skills, while the student-centered approach was most effective at making the course relevant and interesting, and engaging students in their own learning. Both approaches were least effective in promoting student interest in biology as a discipline.

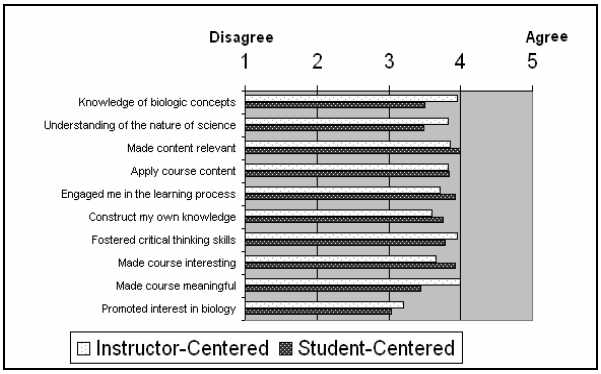

FIG. 1. Student ratings of effectiveness of instructional approach in achieving course goals (n = 94).

Differences in effectiveness in the approaches in

achieving course goals were found (Table 1).

Statement	Average Response Instructor-Centered	Student-Centered	t-value	P-value
1. Developed my knowledge of biologic concepts.	3.96	3.50	4.69	< .001*
2. Developed my understanding of the nature of science.	3.83	3.49	3.74	< .001*
3. Made the content relevant.	3.86	4.00	1.00	< .320
4. Apply course content.	3.82	3.84	-0.10	<. 850
5. Engaged me in the learning process.	3.71	3.92	-2.25	< .027*
6. Construct my own knowledge.	3.60	3.76	-1.39	< .017*
7. Fostered critical thinking skills.	3.95	3.79	-1.58	< .117
8. Made the course interesting.	3.66	3.92	2.13	< .038*
9. Made the course meaningful.	4.00	3.45	2.47	<. 015*
10. Promoted interest in discipline of biology.	3.20	3.04	2.22	<.029*

n = 94
* Statistically significant
TABLE 1. Survey results of student perceptions of electiveness of instructional approach.

Knowledge of Biology: A fundamental goal of the course is to promote student understanding of basic biological concepts. Students perceived the instructor-centered approach to be more effective than the student-centered approach ($p < .001$) in this area. Students' comments indicate that one of the advantages of an instructor-centered approach is the perceived accuracy of the content and authoritativeness of the source, while a disadvantage of the student-centered approach is the perceived uncertainty of the accuracy of student responses.

Understanding of the Nature of Science: An accurate understanding of the nature of science as a method of inquiry is a vital aspect of scientific literacy. Students perceived the instructor-centered approach to be more effective than the student centered approach ($p < .001$) in this dimension. As in 'Knowledge of Biology,' students noted the perceived advantage of the instructor as an authoritative source of accurate information over the uncertainty of the work done by students in the collaborative groups.

Relevance of Course Content: In a course for non-majors the relevance of the content to students' everyday life can be an important aspect of student interest and learning. No significant difference in student perceptions of the effectiveness of instructor-centered vs. student-centered approaches in making the content relevant was found. Students' comments indicate that they found both approaches brought relevance to the content.

Apply Course Content: Fostering students' ability to apply course content to individual and societal issues is an important goal of the course. No significant difference in student perceptions of the effectiveness of instructor-centered vs. student centered approaches in this area was found. Comments indicate that students found this to be an attribute of both instructional approaches.

Engaged in the Learning Process: Engaging students in course content is a powerful method of promoting meaningful learning. Students perceived the student-centered approach to be more effective than the instructor-centered approach ($p < 0.027$) in this dimension. Students noted that engagement was an important aspect to holding their attention and was an advantage of the student-centered approach over the instructor centered approach.

Student Construction of Knowledge: Students learn meaningfully when they can construct their own knowledge. No significant difference was found in student perceptions of the ability of the two approaches to foster student construction of knowledge.

Fostered Critical Thinking Skills: Meaningful learning of scientific/biologic content occurs as students apply, analyze, synthesize and evaluate information. No significant difference was found in student perceptions of the ability of the two approaches to foster critical thinking skills. Students noted that this was a distinguishing feature of the entire course and an attribute of both instructional approaches utilized.

Course Interesting: Maintaining student interest in the course can promote student attendance and engagement. Students perceived the student-centered approach to be more effective than the instructor-centered approach ($p < .038$) in making the course interesting. Many students viewed this to be an advantage of the student-centered approach and a potential disadvantage of instructor-centered approaches when that approach is overemphasized.

Course Meaningful: Designing a non-majors course that students perceive as being personally meaningful is a departmental goal. Students perceived the instructor-centered approach to be more effective than the student-centered approach ($p < .015$) in making the course meaningful. Students' comments indicate that they perceive this to be an attribute of both instructional approaches, but more so for the instructor-centered than the student-centered.

Interest in Biology: Promoting students' interest in biology as a discipline in a non-majors course may result in enrollment in additional biology courses and, potentially, a change of some students' major to biology or a related scientific field. Minimally, this can result in increased scientific literacy, promoting individuals' ability to make informed decisions about scientific/biologic issues facing society. Students perceived the instructor-centered approach to be more effective than the student-centered approach ($p < .029$) in making the course meaningful, but noted that both approaches were useful in this dimension.

Students were also asked to identify the balance of instructor-centered to student-centered instruction they thought was ideal for the course (Figure 2). All students preferred a mix of the two approaches, with the majority of students preferring a predominately instructor-centered approach complemented by student-centered instruction. Many students commented that a diversified approach helped to keep class sessions fresh and interesting.

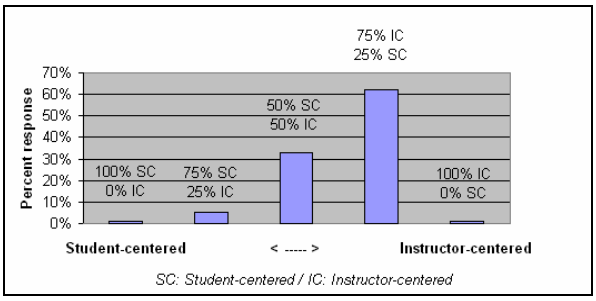

FIG 2. Student instructional balance preference (n = 94).

Discussion and Conclusions

This study describes students' perceptions of the relative effectiveness of student-centered vs. instructor-centered approaches utilized in a one-semester, introductory biology course for non-majors taught by a single instructor. Generally, students indicated that they found both approaches to be effective in achieving course goals and prefer the course to be taught utilizing both approaches. Differences in student perceptions about the effectiveness along some dimensions were found. Students perceived the instructor-centered approach to be most effective in promoting knowledge (biology content and the nature of science as a method of inquiry) and in making the discipline interesting and the course meaningful, while the student-centered approach was perceived to be more effective at making the course interesting and engaging them in their own learning. Students indicated that varying the approach helped to maintain their interest in the course. They valued the ability of student-centered instruction to make the course interesting and the authoritativeness and accuracy of information presented in the instructor-centered approach. As the surveys were anonymous to encourage authentic and reliable responses, no mechanism was available to correlate student

responses with course grades—this is a potential avenue for subsequent research.

These findings provide students' views about instructional approaches and further support the calls for a more diversified instructional approach in university science courses. Developing and employing the content-specific, student-centered activities utilized in the study also highlights several barriers to implementing a diversified approach (Laurer, 2003). The amount of time required to develop, field test, implement and grade the student-centered activities is considerable. Some faculty might find the time and effort required prohibitive. However, one advantage to the use of cooperative learning activities is they can be developed over time and implemented gradually (Allen and Tanner, 2005). While some activities are published in relevant science education journals, or are available as textbook supplements, the limited availability of high-quality, content-specific activities remains limited, and this likely remains a primary reason for the over-reliance on passive, instructor-centered approaches utilized in university science courses. The development and dissemination of resources that support student-centered, active instructional strategies is a vital component of fostering a more diversified instructional approach in university biology courses.

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