Journal of the Scholarship of Teaching and Learning, Vol. 11, No. 2, April 2011, pp. 76 – 90.

Improving student engagement in a lower-division botany course

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Abstract: Active-learning techniques have been advocated as a means to promote student engagement in lower-division biology courses. In this case study, mini-lectures in combination with active-learning activities were evaluated as strategies to promote a culture of learning and participation in a required botany course. These activities were designed to develop critical-thinking skills, i.e. Bloom's synthesis, application, and analysis. Student attitudes toward learning, participation, and class activities were assessed with feedback surveys following each activity, at the beginning with a pre-survey and at the end of the semester with a retrospective survey. Students identified concept maps, problem-solving exercises, and the categorizing grid as helpful to their learning. Based on instructor observations, students were especially engaged in activities that allowed them to demonstrate creativity and resourcefulness. Based on the retrospective survey results, students were more conservative in their perception of personal critical-thinking skills at the end of the semester, which may be a reaction to the challenges in developing critical-thinking skills. The incorporation of mini-lectures with class activities helped to promote student engagement in the classroom and thus, was a positive instructional strategy.

Keywords: biology, participation, undergraduate

I. Introduction.

Introductory biology classes are traditionally delivered two to three times per week, with one three-hour lab section. In general, professors lecture throughout the class period with periodic questioning of students that addresses lower level-order cognitive (LOC) thinking skills. This teaching style can result in nominal student-student and student-professor interactions (Crowe, Dirks, & Wenderoth, 2008). By comparison, the lab sessions are designed to offer the opportunity for active learning that engages the student and develops higher-order cognitive (HOC) skills, e.g. synthesis and analysis (Crowe, Dirks, & Wenderoth, 2008), through active participation and problem-solving.

As an instructional strategy, class group activities aim to promote active engagement during the lecture period. Active engagement is linked to increased motivation to learn, which can translate into a greater likelihood of meeting learning outcomes (Driscoll, 2000). According to Keller's Attention-Relevance-Confidence-Satisfaction (ARCS) Motivational Model, students motivation can be stimulated by including strategies that capture their Attention, provide Relevance of the course material to their needs and goals, stimulate Confidence in succeeding in the course, and provide Satisfaction in their performance (Keller, 1984).

In addition, active-learning class activities provide opportunities for students to develop the critical thinking and problem solving skills necessary to meet HOC learning outcomes (Allen, & Tanner, 2005; Smith, Stewart, Shields, Hayes-Klosteridis, Robinson, & Yuan, 2005).

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To this end, professors should support students' use of deep rather than surface approaches to learning (Hall, Ramsay, and Raven, 2004; Gabriel, 2008; Nelson Laird, Shoup, Kuh, & Schwarz, 2008).

Based on Bloom's Taxonomy, surface learning requires LOC skills such as memory recall and the ability to identify or describe subject material (Crowe, Dirks, & Wenderoth, 2008). By comparison, development of HOC skills promotes greater understanding and extended knowledge retention (Gabriel, 2008). Walker, Cotner, Baepler, and Decker (2008) suggest that combining active-learning activities with mini-lectures increases student engagement, and subsequently student command of the learning outcomes.

Botany is a required course for all biology and marine science majors at our traditional, liberal arts university and is often met with a degree of resistance. Because of the first author's previous experience with student attitudes in the lower-division botany course, she introduced an instructional strategy of mini-lectures combined with active-learning class activities. The authors aimed to investigate whether such a strategy would promote student engagement and positive attitudes towards learning. Activities (concept maps, problem-solving activities, and categorizing grids) were designed to provide relevance of course material, and to develop engaged learning, attention, and HOC skills. These activities were aligned with course objectives and were implemented throughout the fall 2009 semester.

II. Methods.

Because the purpose of this study was to explore the use of instructional strategies in a specific course, the authors employed a mixed methods (Johnson, & Christensen, 2004) research design that focused on a single case. Yin (1994) defines a case study as "… an empirical inquiry that investigates a contemporary phenomenon within its real-life context…" (p. 13), the purpose of which is to "…maximize what we can learn" (Stake, 1995, p. 4). This type of research also has roots in the literature of classroom research and the Scholarship of Teaching and Learning (SoTL) in higher education (Boyer, 1990; Cross, & Steadman, 1996; McKinney, 2007; Weimer, 2006).

In this mixed-methods study, the case study was a lower-division botany course with an enrollment of 36 students. Based on a personal-information questionnaire, 32 of the 36 students identified themselves as biology majors with a pre-professional (medicine, pharmacology, and veterinarian sciences) emphasis or as a marine science major. The remaining students identified themselves as biology majors with interests in the natural sciences. This single case was used to explore the effectiveness of an instructional strategy that combines mini-lectures with class activities in an effort to promote student engagement and develop HOC skills. Interpretations from the case study were drawn from various sources (Merriam, 1998) that included student pre- and post-surveys, feedback surveys, personal observations, test scores, and attendance records.

To explore the possible impacts of class activities on student learning, we compared mean exam scores between the fall 2009 course to scores from a similarly-sized class that was taught by the same professor in spring 2009, without class activities. The scores were used solely for a qualitative comparison because we could not treat the spring course as a control. Our study had received ethics approval from the university's Institutional Review Board.

A. Instruments.

Student motivation for learning is multidimensional and therefore hard to measure accurately with only Likert-style instruments. Fulmer and Frijters (2009) suggest that more authentic measures of motivation might be "…participant observation, case studies, and semi-structured, retrospective surveys…" (p. 231). Our case study used semi-structured self-report surveys to collect both quantitative and qualitative data related to individual experiences (e.g. motivation) for each instructional strategy.

The self-report surveys included a pre-survey given at the beginning of the semester, a retrospective survey given at the end of the semester, and a survey following each class activity. All surveys were anonymous and voluntary and had received ethics approval by the Instructional Review Board prior to the study. The surveys assessed students' general attitudes toward the learning process, group participation, and personal critical-thinking skills (see Appendix 1) and were administered during the first day of class and at the end of the semester. To better understand students' perceptions of prior knowledge, the pre-surveys also included questions regarding their familiarity with photosynthesis, stages of meiosis/mitosis, plant life cycles, plant diversity, and plant cellular biology.

After each activity, students' attitudes toward class activities were measured according to their self-reported perceptions regarding three of the four components of Keller's (1984) motivational model: relevance, confidence, and satisfaction. To measure perceived relevance and confidence, the surveys asked the students to rank their ability to apply material learned from the text ('I felt that I could apply what I learned from the text for this activity') and lecture ('I felt that I could apply what I learned from the lecture for this activity'). To further measure confidence in their grasp of the material, students were asked 'After doing the activity, I felt more confident about knowing the material'. To measure satisfaction, the surveys asked the students to rank the question 'I found the activity useful for my learning of this material'. The surveys also gave students the opportunity to provide narrative feedback regarding the value of and suggestions to improve each activity. To increase satisfaction, the instructor sent emails summarizing the students' responses and identified adjustments to future activities. In addition, the students were asked to rate their level of participation ('I participated in the group activity').

B. Activities.

To ensure that students had read assigned material in the textbook prior to lecture, completion of online quizzes was required on a weekly basis. These quizzes targeted the LOC skill of recall of terminology and processes. Detailed lecture notes were made available online via the university's course management tool, and were used to supplement lectures given during class. Video clips downloaded from the Internet were used to further illustrate material presented during each lecture.

A combination of active-learning activities with mini-lectures was used as an instructional strategy to promote engagement and command of learning outcomes (Walker, Cotner, Baepler, & Decker, 2008). The activities were multi-faceted, drew upon previous knowledge, and allowed for confidence building. Keller's (1984) ARCS Motivation Model identified such attributes as essential to student learning (Driscoll, 2000).

Mini-lectures were used to deliver content and aimed to circumvent resistance from students unused to directing and applying their own learning (Allen, & Tanner, 2005). The activities were varied to meet the session learning outcomes and to increase interest for learning (see Table 1). Specifically, concept maps, problem-solving activities, categorizing grids, and approximate activities were designed to target HOC skills of synthesis, analysis and application (see Table 1, Angelo, & Cross, 1993; Crowe, Dirks, & Wenderoth, 2008).

We used a course design that alternated between 1) sessions dedicated entirely to lectures with five-minute breaks during the 75-minute class period and 2) sessions that incorporated active-learning activities. On days that included a class activity, the instructional design followed a prescribed order: mini-lecture, activity, debriefing of activity with feedback, and the completion of feedback survey. The relevance of each activity was explained in the syllabus and in the introduction of each activity. In an effort to promote student confidence, immediate feedback was provided to individuals during each activity and with guided class discussions following each activity.

Student satisfaction was assessed with feedback surveys immediately after each activity and then reported back to the students with a summary of their comments by email. In addition, detailed feedback was provided throughout the class period, as suggested by Walker, Cotner, Baepler, and Decker (2009), Reddy (2000), and Chickering and Gamson (1987). The constant feedback allowed students to demonstrate learning outcomes and to address any gaps in their knowledge, and thus helped to build student confidence (Chickering, & Gamson, 1987; Keller, 1987).

C. Analyses.

One-way analysis of variance was used to test for differences among the six activities (N = 25 respondents) and between responses from surveys given at the beginning and end of the semester (see Appendix 1). In an effort to keep an equal sample size for univariate statistical tests, the lowest sample size from one collection of feedback surveys was used, although numbers ranged between 25 and 34 respondents per activity. Responses from the pre-survey were not significantly different from the retrospective pre-responses, $p > 0.05$. For this reason, a paired t-test was used to test for differences between the retrospective survey responses (designated with a 'Retro-pre' and 'Retro-post' in Appendix 1). Assumptions of normality and equal variances were assured before conducting each test.

We used exam scores from two botany courses to explore whether the inclusion of class activities may have contributed to student performance. Mean exam scores from the fall 2009 course were compared to scores from a similarly-sized class that was taught by the same professor in spring 2009, without class activities. Exam questions from both classes included short answers that targeted skills in synthesis, analysis and application of course material.

III. Results.

A. Initial and retrospective surveys.

At the beginning of the semester, students were asked to rate their critical-thinking skills and attitudes towards learning. Student perception of their critical-thinking and communication skills and attitudes toward learning were more positive (1 = strongly disagree, 3 = agree, and 5 = strongly agree) than their perception of group activities. Mean responses (± 1SE) to the statements "I feel that I have good critical-thinking skills" and "I feel that I have excellent

Table 1. Description of in-class activities that target critical-thinking skills, based on Angelo and Cross (1993).

Specific skill	Topic	Instructional strategy/activity
[1]Synthesis, [3]Application	Nutrient uptake pathway of a nutrient, molecules that utilize the nutrient, and functions of those molecules in a plant cell	*Concept maps to assess connections.* Given illustrations of a plant and plant cell, students were asked to identify uptake pathway and organelles that utilize molecules composed of given nutrient. Functions of each molecule were described alongside each organelle. In addition, students were asked to link the different levels (plant, leaf, and cell) to show connections from the macroscopic to intracellular scales.
[1]Synthesis [2]Analysis	Evolution of traits for photosynthetic organisms	*Concept maps to assess connections.* Students were asked to draw a circle around each photosynthetic group and a line between groups that are evolutionarily most similar. Next to each line, students wrote down traits shared between the two groups. This activity required students to identify features that show similarities among groups (life cycles, chlorophyll *a*) and also how they diverged (vascular tissue, accessory pigments, seeds, flowers).
[1]Synthesis, [3]Application	Respiration and fermentation processes	*Problem solving.* Students were asked to debate whether growing corn for fuel or food is more efficient, based on energy required for respiration and fermentation
[1]Synthesis, [3]Application	C3, C4, and CAM pathways	*Problem solving, concept maps.* Students were asked to trace the pathway of inorganic carbon/water uptake at the organismal level to synthesis of sugar at the cellular level for C3, C4, and CAM plants. Students were given the sugar (cane sugar, maple syrup, and cactus juice) as a starting point.
[2]Analysis	Movement of molecules via osmosis, passive/facilitated diffusion, and vesicle-mediated transport	*Categorizing grid.* Students were asked to fill in a table during lecture that compared ways in which compounds and large molecules enter/exit plant cells.
[1]Synthesis, [3]Application	Life cycles of algae and fungi	*Approximate analogies*. Students were asked to create an illustrated children's story based on either an alga or fungus life cycle that includes when fertilization and meiosis occurs, haploid and diploid generations and what each generation produces (gametes or spores).

Note: [1]Synthesis: reorganizing information; [2]Analysis: taking apart information; and [3]Application: using knowledge to solve problems (Angelo and Cross, 1993)

communication skills" were 2.7 (± 0.2) and 2.5 (± 0.2). Mean responses to the statements "I enjoy the process of learning" and "I think that I will enjoy learning about botany this semester" were 2.9 (± 0.2) and 2.8 (± 0.2), respectively. Students were less positive towards group participation. In response to "I feel that group activities help me to learn course material", "I actively participate in group activities to improve learning", and "I feel that I learn material better by participating in critical-thinking group activities" were 2.6 (± 0.3) and 2.6 (± 0.2), and 2.7 (± 0.25), respectively.

Students were asked about their familiarity with specific biological concepts. Of the 33 respondents, all were familiar with photosynthesis, 97% were familiar with mitosis/meiosis, 67%, and 70% of the students were familiar with plant life cycles and plant diversity. Only 52% were familiar with plant cellular biology.

To investigate changes in student perception after a semester of participation in the class activities, students were asked to rate their critical-thinking skills and attitudes towards learning using a retrospective survey. Students were significantly more conservative in their assessments of their critical-thinking skills at the end of the semester (paired $\text{t-test}_{27} = 2.88$, $p = 0.008$; see Figure 1). In addition, they were significantly less positive towards the process of learning by the end of the semester (paired $\text{t-test}_{27} = -2.87$, $p = 0.008$, see Figure 1). Students showed no significant changes in attitudes towards their participation in group activities and activities that targeted critical-thinking skills ($p > 0.090$; see Figure 1).

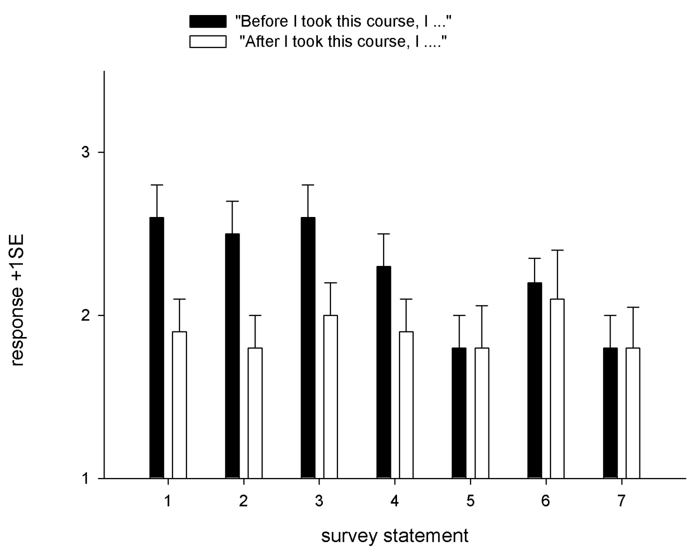

Figure 1. **Mean student responses (+ 1SE) to the retrospective survey given at the end of the semester.** Survey responses: 1 = strongly disagree, 3 = agree, and 5 = strongly agree. Retrospective pre-statements began with "Before I took this course, I ,…". Retrospective post-statements began with 'After I took this course, I….'. Retrospective pre- vs post- survey statements: 1) I felt that I had good critical-thinking skills vs. I felt that I increased my critical-thinking skills; 2) I enjoyed the process of learning vs. I feel that I have a greater interest in the process of learning; 3) I thought that I would enjoy learning about botany vs. I felt that I enjoyed learning about botany; 4) I felt that I had excellent communication skills vs. I feel that I have stronger and more effective communication skills; 5) I felt that group activities help me to learn course material vs. I found that group activities help me learn course material; 6) I would actively participate in group activities to improve my learning vs. I feel that I am more willing to actively participate in group activities to improve my learning; and 7) I felt that I learned

material better by participating in critical-thinking group activities vs. I feel that I learn material better by participating in critical-thinking group activities. N = 25 students.

B. Activities surveys.

In general students did not identify any activity as being especially helpful or ineffective to their learning (see Figure 2). Post-activities responses were not significantly different ($p > 0.46$, N = 25 students) among the six activities with application of their knowledge from the text and lecture, usefulness of the activity to their learning, and participation in the activity. A significant difference was identified ($F_{5,\,144} = 2.79$, $p = 0.019$, see Figure 2) with respect to confidence in the material. Tukey's pairwise comparisons indicated that students felt more confident following the debate (2.8 ± 0.2) as compared to the nutrient-uptake activity (1.7 ± 0.2; $p = 0.014$; see Figure 2).

In order to evaluate students' abilities to apply course material, we compared first and final mean exam scores between the fall 2009 course to scores from a similarly-sized class that was taught in spring 2009, without class activities. Mean exam scores suggested that students in the fall course were better able to apply course content by the end of the semester (see Table 2). Exam scores increased over the fall semester, with mean (± 1SE) exam scores of 77% (± 2.9) for the first exam and 85% (± 2.6) for the fourth exam. By comparison, the spring semester scores were 78% (± 3.7) for the first exam and 61% (± 4.7) for the fourth exam (see Table 2). Mean daily attendance (80%) was the same for both semesters.

Table 2. Student mean exam scores (% ± 1 SE) from fall 2009 (class of 36 students) and spring 2009 (class of 34 students) botany courses (N = 4 exams). Fall 2009 included class activities.

Exams	Spring 2009 No class activities	Fall 2009 With class activities
First	77.6 ± 3.7	77.2 ± 2.9
Second	78.0 ± 4.3	69.7 ± 3.0
Third	73.6 ± 4.2	85.5 ± 2.7
Final	60.7 ± 4.7	84.6 ± 2.6

The narrative feedback from each survey provided information regarding student feelings immediately following each activity. In general, students appreciated the group activities and were cognizant of how the activities were tied to course material. Students remained on-task during the activities, talking among themselves and utilizing their text, phones, and computer as research tools. With respect to the ethanol debate, students described the discussion as "spirited", "intense", and "active", and appreciated learning how the material (respiration and fermentation) "applied to the real world". For many, the topic was an "eye opener". The atmosphere during the research period prior to the debate ranged from one of intense concentration to light-hearted exchange.

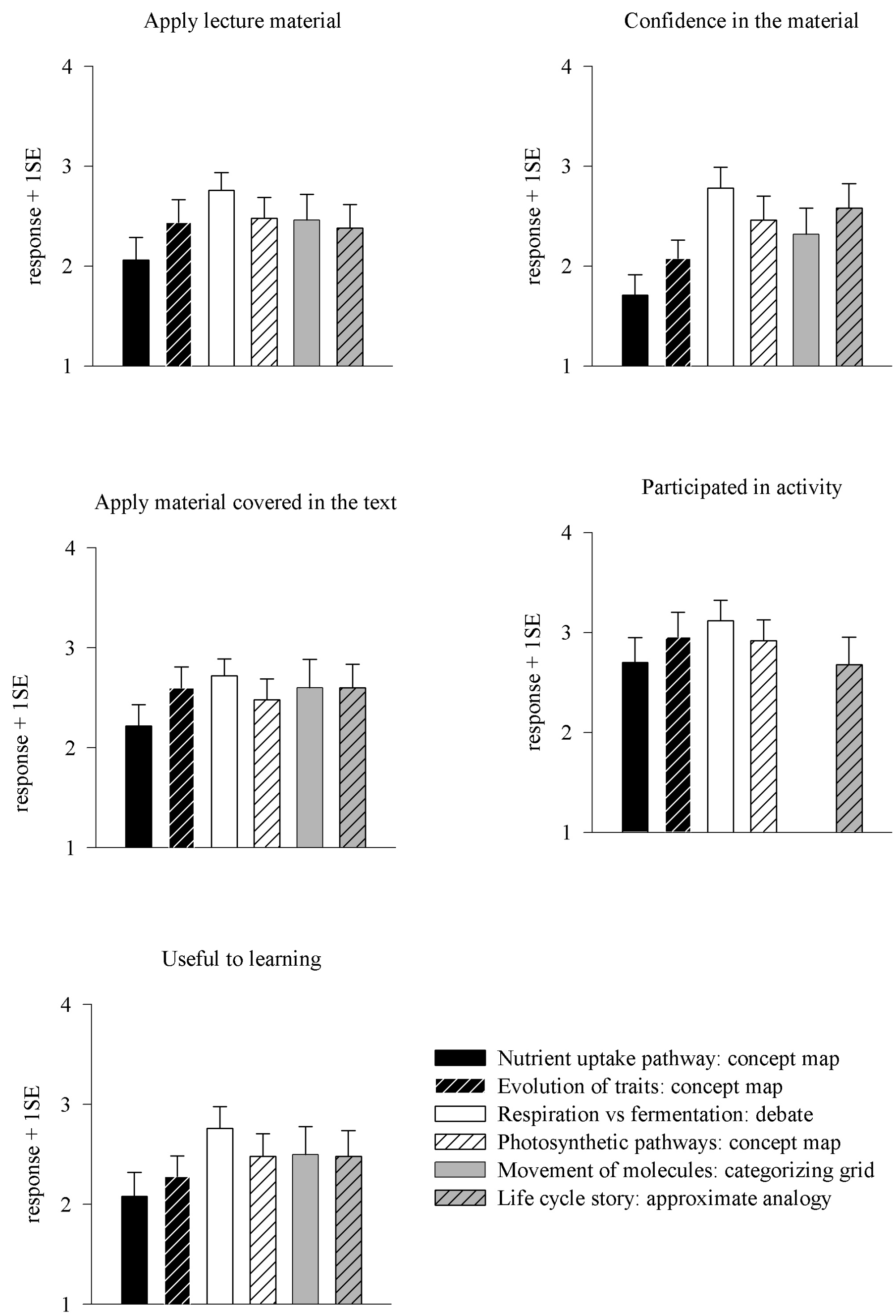

Figure 2. Mean responses (+ 1SE) of students to survey statements that assessed their ability to apply material from the lecture and text to the activity, usefulness of the activity to their learning, confidence in the material following the activity, and participation during the activity. 5 = strongly agree, 3 = agree, and 1 = strongly disagree. N = 25 students. Table 1 provides a description of each activity. Participation was not surveyed for the 'Movement of molecules' activity.

Students were introduced to different ways to study the material. In particular, they learned how to organize their notes (categorizing grid) while listening to lectures and to synthesize the material (concept maps). During the feedback period following the activity, students admitted that the concept map was new learning tool. From the written surveys, students wrote that they appreciated “seeing the information visually”, that the maps “showed links, organized traits”, and “related everything together”. Many enjoyed the activities that allowed them to draw with crayons and sidewalk chalk (photosynthesis diagram and life cycle activities). One student volunteered that “drawing made me want to participate” and others identified how the activity “showed connections of photosynthesis”. In response to the photosynthesis activity, another student had written that, in participating, they were able to “focus on the details, actually learn, and it helped a lot to understand it better”. When commenting on the life-cycle activity (see Table 1), one student admitted that they were “skeptical at first- that it was different, but that I (*the student*) understood what I (*the student*) was teaching (*to the rest of the class*)”. As a whole, the students enjoyed that the activity was outside and challenged them to think creatively.

At the end of the semester, the student attitudes were generally positive about the course’s goals in promoting learning with activities that targeted HOC skills. Based on narrative responses, one student reflected that this course “made me want to focus and go more in depth with my studies” and introduced me to “new ways of studying”. Another student wrote that botany was “far more interesting and fun than I thought”. Many students appreciated the group interactions with similar comments that ‘group activities make clear what my weaknesses are and allow me to gain an understanding of the material’ and an opportunity to “learn from other people”. One student noted that the class activities “facilitate greater exposure to material and different ways of applications”.

Based on the narrative feedback, students recommended changes primarily related to classroom and time management and highlighted the need for further clarification of some activities. Students requested more time to work on the activities, to do more research for the debate, and to cover more life cycles. They asked to have time at the end of each session to review the activities as a class, to be able to pick group partners, and to have smaller groups. Students mentioned that lecture-hall setting with fixed seats made it challenging to work in groups. Although some students did appreciate the categorizing grid, a number of students found the note-taking activity confusing. The concept map was considered the most confusing to those who preferred “a structured shell” that was provided by the instructor.

IV. Discussion.

Active-learning activities with mini-lecture helped to promote student engagement and achievement of HOC learning outcomes in a lower-division botany course. Student motivation was sustained throughout the semester, as indicated by an 80% average attendance, and a mean of greater than 70% on exam scores. Student-professor and student-student interactions, diversity in instructional strategies, and relevance of the activities to learning outcomes likely contributed to student interest in participation (Chickering, & Gamson, 1987; Keller, 1987). Despite gains in engagement, students were more conservative in their critical-thinking (HOC) abilities following a semester of class activities, indicating the complexities inherent in student motivation.

Students reacted most positively to activities that required research and creativity. For example, the ethanol debate (problem solving), life cycle (approximate analogy) and photosynthesis (concept map) activities were given strong scores following the activities. The ethanol debate addressed a topical and controversial subject that may have encouraged friendly competition among students, which can stimulate motivation (Keller, 1987). The life cycle and photosynthesis activities allowed students to demonstrate their understanding in a visual context that may not be otherwise possible in a typical lecture format. Students indicated in their comments the value in “seeing the information” that “showed links” and “connections”. We suggest that in addition to providing relevance, student creativity is a factor to be considered when designing class activities.

Our instructional strategy of utilizing active-learning techniques may have contributed to academic performance in addition to promoting student engagement. We observed gains in mean exam scores over the course of the semester (gain of +7% between first and last exam with a final exam score of 84%) as compared to a botany course taught without class activities the previous semester (loss of -17% between first and last exam with a final exam score of 61%). Similarly, Reddy (2000) reported mean final exams of 90% in a pharmaceutical class utilizing active-learning techniques as compared to 80.5% in a similar class taught traditionally with lectures. Walker, Cotner, Baepler, and Decker (2008) reported a mean final percentage score of 75% and 71.5% in an introductory biology course with (n = 263 students) and without (n = 240) active-learning techniques, respectively.

Despite evidence in student engagement during class activities, students did not report significant gains in confidence with respect to their critical-thinking skills at the end of the semester. Interestingly, Walker, Cotner, Baepler, and Decker (2008) also reported a drop in student confidence towards ‘science-related skills and knowledge’ following a semester of active-learning activities. Perhaps the challenging nature of the activities contributed to a more conservative perception of their personal critical-thinking skills and of the learning process. In addition, the lack of a neutral value on our ranking scale may have confused the students.

Another explanation for the lack of significant change between students’ pre- and post-self-reports of change in content-specific and critical-thinking abilities could be related to response shift bias (Drennan, & Hyde, 2010) and therefore a move from a naive to more expert mental model (DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008). Response shift bias is the reconceptualization of a construct due to an intervention (e.g. instruction) that results in students “… rating their ability on a different dimension or metric at time two (post-test) due to the development of a greater understanding of the construct under investigation” (Sprangers, 1988 as reported in Drennan, & Hyde, 2010, p. 700). While we did employ a retrospective survey design to try to control for this type of bias, we did not specifically match pre-survey given at the beginning of the semester and the retrospective survey by respondent.

We argue that the instructional strategy of mini-lectures combined with activities targeting higher-order cognitive (HOC) skills succeeded in promoting a culture of student engagement in a course that had been met previously with student reluctance. Based on this case study we advocate an instructional strategy that includes mini-lectures with active-learning activities designed to promote learning outcomes and interactions with the students (Chickering, & Gamson, 1987; Reddy, 2000). At the end of the semester, many students described the course as interesting and appreciated being exposed to new ways of learning. Engagement, participation, and positive attitudes were apparent with the balance between class activities and lectures despite the limitations of a lecture-hall setting. In the future, we would ask students to write a reflection essay at the end of the semester that addresses their confidence towards learning and their critical-thinking skills, to better understand changes in perception from the beginning and end of the semester. In an effort to better address the multidimensional nature of student motivation, future research studies will be designed to look at more authentic ways of measuring motivation.

Acknowledgements

We thank Jacksonville University's The Marilyn Repsher Center for Teaching and Learning Center for institutional support (NG). We thank the botany class for their participation. This study was strengthened by the comments of J. Heine and reviewers.

Appendix 1. Seven survey statements given to the students at the beginning of the semester with a pre-survey (designated with Pre.) and end of the semester with a retrospective survey (designated with Retro-pre. and Retro-post.)

#	Survey statement	Strongly Disagree		Agree		Strongly Agree
1	**Pre.** I feel that I have good critical thinking skills (ability to solve problems based on material presented in the class).	1	2	3	4	5
	Retro-pre. Before I took this course, I felt that I had good critical-thinking skills (ability to solve problems based on material presented in the class).	1	2	3	4	5
	Retro-post. After I took this course, I felt that I increased my critical-thinking skills.	1	2	3	4	5
2	**Pre.** I enjoy the process of learning.	1	2	3	4	5
	Retro-pre. Before I took this course, I enjoyed the process of learning.	1	2	3	4	5
	Retro-post. After I took this course, I feel that I have a greater interest in the process of learning.	1	2	3	4	5
	Please add comments to your response:					
3	**Pre.** I think that I will enjoy learning about botany.	1	2	3	4	5
	Retro-pre. Before I took this course, I thought that I would enjoy learning about botany.	1	2	3	4	5
	Retro-post. After I took this course, I felt that I enjoyed learning about botany.	1	2	3	4	5
	Please add comments to your response:					
4	**Pre.** I feel that I have excellent communication skills (writing, listening, speaking, reading, interacting).	1	2	3	4	5
	Retro-pre. Before I took this course, I felt that I had excellent communication skills (writing, listening, speaking, reading, interacting).	1	2	3	4	5
	Retro-post. After I took this course, I feel that I have stronger and more effective communication skills (writing, listening, speaking, reading, interacting).	1	2	3	4	5
	Please add comments to your response:					

5	**Pre.** I feel that group activities help me learn course material.	1	2	3	4	5
	Retro-pre. Before I took this course, I felt that group activities help me learn course material.	1	2	3	4	5
	Retro-post. After I took this course, I found that group activities help me learn course material.	1	2	3	4	5
	Please add comments to your response:					
6	**Pre.** I actively participate in group activities to improve my learning (share ideas, listen to others, incorporate ideas of others).	1	2	3	4	5
	Retro-pre. Before I took this course, I would actively participate in group activities to improve my learning (share ideas, listen to others, incorporate ideas of others).	1	2	3	4	5
	Retro-post. After I took this course, I feel that I am more willing to actively participate in group activities to improve my learning.	1	2	3	4	5
	Please add comments to your response:					
7	**Pre.** I feel that I learn material better by participating in critical-thinking group activities.	1	2	3	4	5
	Retro-pre. Before I took this course, I felt that I learned material better by participating in this critical-thinking group activities.	1	2	3	4	5
	Retro-post. After I took course, I feel that I learn material better by participating in critical-thinking group activities.	1	2	3	4	5
	Please comment to your response:					

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