Active learning increases performance in STEM courses, but many instructors are hesitant to adopt active-learning practices because they are afraid students will have negative attitudes toward them. It was hypothesized that students whose first college biology experience was in a course that used active learning would have more positive attitudes toward active learning than students who initially experienced a traditional lecture-based course. Students in an introductory Cell Biology course were queried regarding their attitudes toward active-learning practices used in the class. Responses to a Likert-scale survey indicated that students had positive attitudes toward active learning, and an analysis of variance indicated that there were no significant differences between the attitudes of students who had previously taken a lecture-based biology course at the same institution, students who had previously taken a biology course at another institution, and students who were enrolled in Cell Biology as their first college biology experience (n = 52, P = 0.530). Students strongly favored active-learning techniques over passive techniques but were less convinced of their learning benefits. Experienced students indicated that they preferred the teaching methods used in Cell Biology over the techniques used in their prior biology course. The results indicate that in the context of a small classroom setting, most students have positive attitudes toward active learning regardless of their prior biology lecture experiences.

Key Words: attitudes toward science; active learning; STEM education; lecture.

Introduction

Active learning can be defined as any pedagogy that causes students to spend class time engaged in answering questions, solving problems, discussing solutions with their peers, and reasoning about the material they are studying, all while getting regular feedback from their teacher (Weiman, 2014). Numerous studies have shown that active learning increases student performance in STEM courses (reviewed by Springer et al., 1999; Freeman et al., 2014) and retention in STEM majors (reviewed by Springer et al., 1999; Graham et al., 2013). In introductory biology courses, active learning has repeatedly been shown to increase student performance (Freeman et al., 2007, 2011). Several national agencies have issued documents or started programs that aim to increase the use of active learning in college STEM classrooms, including Vision and Change (AAAS, 2015), the WIDER program (National Science Foundation, 2013), and a recent “call to action” to improve STEM education through active learning by the White House Office of Science and Technology Policy (Handelsman & Brown, 2016).

While most studies of active learning in STEM have focused on learning and retention outcomes, some have also examined student attitudes toward active learning, and a subset of these studies have indicated that students have positive perceptions of active learning. Students in a human physiology course that used active learning had positive attitudes toward the technique and believed that it helped them learn the material (Wilke, 2003). Dental students (Miller & Metz, 2014) and pharmacology and information technology students (White et al., 2005) were also found to have positive attitudes toward active learning. Studies of active-learning use in introductory biology have shown that students rated their instructor quality as higher when active learning was used rather than passive lecture (Armbruster et al., 2009).

While there are many favorable outcomes associated with use of active learning in STEM classrooms, some studies have shown that students resist active learning and have negative attitudes toward its use. A study examining the use of active learning in a physiology course found that while active learning increased course grades, compared to students in traditional lecture sections, students in active-learning sections perceived that they had learned less and that their instructor was less effective (Lake, 2001). In a study that compared the use of a flipped classroom to a more traditional lecture in a non-majors biology course, it was found that students in the flipped classroom had consistently negative perceptions of the technique, despite no difference in grades between the sections (Bernot & Metzler, 2014). Surveys of students in math and science courses at one large university revealed that ~30% of second- to fourth-year students perceived active learning as unimportant or only slightly important for their learning (Welsh, 2012).
Students’ explanations for their negative attitudes toward active learning are varied. Some say that the techniques are a waste of time or money (if they have to purchase clickers), or that group work is pointless because their group-mates get off track or don’t want to participate (Welsh, 2012). Students also commonly refer to active learning as “not teaching,” indicating that they perceive only lecture as true teaching, whereas when they do active learning they are being forced to teach themselves (Bernot & Metzler, 2014).

Differences in student perceptions of active learning could be due to many factors. Certainly, the type of active learning used and the use or non-use of best practices might influence students’ attitudes toward active learning (Felder, 2011). In fact, some students have commented that the effectiveness of a given active-learning technique varies widely depending on how it is used (Welsh, 2012). The level of the course (undergraduate or graduate, 100 or 400 level) and the size of the class might also have an influence. It is also possible that their prior experiences in college biology courses could influence their attitudes. Seidel and Tanner (2013) hypothesized that students might resist active-learning pedagogies for the same reasons that faculty resist their implementation: they are not trained or experienced in participating in active learning, active learning requires more work, they may not be convinced of the learning benefits, and it may go against their preconceived notion of what their role is in the classroom (to listen and take notes).

There are a variety of reasons why instructors are hesitant to switch from traditional lectures to lectures that incorporate active-learning techniques, but concerns about student push-back and negative evaluations certainly play a role. In one study, 16% of biology faculty indicated that teaching evaluations based on students’ ratings influenced the teaching methods they selected (Lund & Stains, 2015). In responses to an open-ended survey question asking engineering instructors about barriers to implementation of research-based teaching methods, “student resistance” was the fourth-most-common response, behind “class time,” “preparation time,” and “lack of evidence” (Froyd et al., 2012). A related study demonstrated that concern about negative student reactions was a barrier to implementation of a wide variety of research-based teaching practices (Prince et al., 2013). Many studies examining barriers to use of active learning have been performed at large public universities, but even at a small private university it was found that some faculty were hesitant to use active learning because of concerns about student expectations and evaluations (Michael, 2007). While these concerns may be legitimate, it can be argued that most student complaints about active-learning pedagogies are a result of either a mistake in implementation of the method or student dissatisfaction with some other aspect of the course (Felder, 2011).

Context of the Study

This study was conducted at a small, private, liberal arts college where biology majors often experience a traditional, lecture-style biology course (Organismal Biology) before experiencing a course that intentionally incorporates active-learning techniques (Cell Biology). Students enrolled in Cell Biology were surveyed and interviewed to explore their prior undergraduate biology course experiences and their attitudes toward active learning. It was hypothesized that students who experienced a traditional, lecture-format biology course as their first college biology course would have more negative attitudes toward active learning than students who experienced active learning in their first college biology course. It was found that most students had positive attitudes toward active learning, and those who had taken a prior biology course, even if it was a traditional lecture, were more apt to recognize that active-learning techniques help them learn.

Methods

Participants

All methods were approved by the college’s Institutional Review Board, and informed consent was obtained from all participants. Participants in this study were students enrolled in Cell Biology, an introductory course aimed at science majors, at a small, private liberal arts college in fall 2015 (1 section, 28 students) or spring 2016 (1 section, 63 students). Some of these students had completed the other course in the introductory biology series for science majors, Organismal Biology. Cell Biology is taught using active-learning pedagogies (think-pair-share, verbal questioning, clickers, student participation in skits demonstrating cellular processes, etc.) in addition to traditional lecture supported by PowerPoint slides (sometimes including embedded videos and diagrams of cellular processes), whereas Organismal Biology is taught using almost exclusively lecture accompanied by large numbers of detailed PowerPoint slides (provided online and in class in lieu of a textbook). All sections of Organismal Biology are taught by a single instructor, and all sections of Cell Biology are taught by a different single instructor. The instructors for both courses have been teaching these particular courses for >10 years.

Electronic Survey

Approximately two-thirds of the way through the semester, all students in Cell Biology were recruited via email to complete an online “Survey of Student Attitudes toward Lecture Activities” (Table 1). Participants were assured that their instructor would not see their individual survey responses and that only pooled anonymous data would be supplied to instructors. Survey participants were offered an incentive of being entered in a drawing to receive a $25 credit at the campus bookstore. Participants were asked to complete a 26-item, five-point Likert-scale survey adapted from Wilke (2003) and vetted by colleagues in the Biology Scholars Program Research Residency. On the Likert scale, an answer of 1 = strongly disagree (very negative attitude toward active learning), 2 = disagree (negative attitude toward active learning), 3 = neutral, 4 = agree (positive attitude toward active learning), and 5 = strongly agree (very positive attitude toward active learning). Responses from students <18 years of age were excluded from analysis. Approximately half of the items were reverse coded for analysis. Three survey items related to clickers were eliminated from the analysis because clickers were not used in Cell Biology in spring 2016. Cronbach’s α was calculated for the remaining 23 items using all of the survey data, and three items were identified as reducing the Cronbach’s α value. These three items, a subset related to learner responsibility, were excluded from further analysis. The average of the remaining 20 items was calculated for each student, and the averages of various groups of students were compared using analysis of variance.
Table 1. Items on the “Survey of Student Attitudes toward Lecture Activities.”

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Reverse Coded?</th>
<th>Included in Final Analysis?</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like participating in group discussions in class.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>I do not think using clickers in class helps me to learn the material.</td>
<td>Y</td>
<td>N&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>I learn more from doing than from listening.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Participating in group discussions and activities makes me feel uncomfortable.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>The skits we did in class were fun.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>I enjoy using clickers in class.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>I prefer to listen to lecture in class, then work problems as homework.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>I like interacting with others in class.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>I learn more from lecture than from activities.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Working problems in class is an effective way for me to learn material in biology.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>The activities used in lecture were a waste of time.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Working problems in class did not help me to learn the material.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>I wish more instructors would include clicker questions in their lectures.</td>
<td>N</td>
<td>N&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>I learn best when I am an active participant in class.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>I prefer classes where lecture is the only mode of instruction.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>I do not enjoy group discussion or activities.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>I would choose a course that incorporates clickers and activities over a traditional lecture course in the future.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>I believe that I am ultimately responsible for my own learning.</td>
<td>N</td>
<td>N&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lectures are an effective way for me to learn material in biology.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>I believe it is the instructor’s responsibility to ensure that I learn.</td>
<td>Y</td>
<td>N&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Active learning (activities, discussion, clickers) would be a great addition to other courses I’m taking.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>In the future I would choose a traditional lecture course over a course that incorporates clickers and activities.</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>The activities in lecture helped me to learn.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>The skits we did in class helped me to remember the material.</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>A good instructor covers all of the relevant course material through lectures.</td>
<td>Y</td>
<td>N&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>I thought the skits we did in class were a waste of time.</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

<sup>a</sup>Excluded because clickers were not used in spring 2016.
<sup>b</sup>Excluded because this item reduced the reliability (Chronbach’s α) of the instrument.
(ANOVA). Demographic information about participants was collected, including their first college biology course.

**Focus-Group Interviews**

Students were recruited via email for participation in focus-group interviews. An incentive of a free pizza lunch was offered. Participants were assured that their instructor would not see their individual focus-group transcripts, and only anonymous data regarding themes and select quotes would be available to instructors. All interested students were invited to participate. The students (n = 8) were asked questions regarding their attitudes toward various teaching techniques used in biology lecture, and to compare their prior biology course to Cell Biology. Focus-group interviews were video recorded and then transcribed before looking for themes.

**Paper Survey**

Participation in focus groups was unexpectedly low, so a paper follow-up survey was given to all students in Cell Biology during the last week of class. The survey was administered by the researcher, the instructor was not present in the room, and students were assured that only pooled anonymous data would be supplied to the instructor. Completion of the survey was optional, but most students who were present in class completed the survey, and all who completed the survey were >18 years old and consented to the use of their responses for research purposes (n = 59). This survey asked questions similar to those asked of focus-group participants, including the following:

- In your biology course, your instructor asked you to do a variety of activities in class to assist in your learning. These may have included participating in discussion, listening to lecture, performing group work, watching videos, using clickers, performing skits, and other activities. What was your favorite activity in biology lecture and why?
- Focusing on the lecture portion of your biology course, what do you feel is the most effective way to learn biology in class? Why?
- If Cell Bio wasn’t your first college biology course, tell me how the instructional techniques used in your first college biology course compared to the instructional techniques used in Cell Bio. What was the same? What was different? Which did you prefer and why?

Thematic analysis (Libarkin & Kurdziel, 2002) was used to identify common themes in the survey responses and develop categories, and then student responses were binned into the categories and quantified. Two researchers did this process independently, then reconciled any differences in categories and binning. This survey also included a question asking students to select the approximate percentage of time they spent doing activities (discussion, answering verbal questions, group work, etc.) rather than listening to lecture in Cell Biology and any prior biology courses. Responses to this question were analyzed as categorical data, and a chi-square test was used to determine whether there was a difference in the distribution of responses between the classes.

**Results**

Students enrolled in Cell Biology perceived that active-learning pedagogies were being used in the course, and most students reported that Cell Biology included more active learning than any prior biology course they had completed (Organismal Biology or a course taken at another institution). As shown in Figure 1, most students recognized that active learning was taking place in Cell Biology, with students most frequently reporting that 20% of class time was being spent on activities. Most students also reported that their prior biology course(s) had been lecture-based; the most common response was that their prior biology course did not include any activities (0%). It is worth noting, however, that chi-square analysis indicates that the distribution of answers for the two courses does not differ significantly ($\chi^2 = 9.37$, df = 7, 0.5 > P > 0.1).

Students were surveyed to determine their attitudes toward active learning using a Likert-scale instrument adapted from Wilke (2003). Figure 2 illustrates that regardless of whether they had previously completed a lecture-based biology course, students generally had positive attitudes toward active learning. Students without prior college biology experience had a mean score of 3.7825 ± 0.49, those who had completed Organismal Biology (a lecture-based course)
had a mean score of 3.6841 ± 0.39, and those who had completed some other college biology course had a mean score of 3.905 ± 0.77. An ANOVA indicated that there were no significant differences between these groups (P = 0.530, Chronbach’s α = 0.842).

After students completed the Likert-scale survey, an open-ended follow-up survey and interviews were conducted to learn more about students’ attitudes toward active learning. In the follow-up survey, students were asked what their favorite activity was in lecture and were given some examples of activities (participating in discussion, listening to lecture, performing group work, watching videos, using clickers, performing skits, and other activities). As shown in Figure 3, both students enrolled in Cell Biology as their first biology course (79%, n = 5330) and students who had previously taken a biology course (87%, n = 23) indicated that a passive technique (listening to lecture, looking at PowerPoint/visuals, or watching videos) was the most effective way for them to learn, but 58% of students taking a college biology course for the first time (n = 31) indicated that a passive technique (listening to lecture, looking at PowerPoint/visuals, or watching videos) was the most effective way for them to learn, but 25 indicated that skits helped them “learn” or “understand” when explaining why that was their favorite activity in their open-ended responses.

In focus-group interviews (n = 8), some students reported that they preferred passive activities such as lecture (“I like just listening to the lecture, because she explains everything”) or watching videos (“I like videos because it helps to kinda like show what’s actually going on visually”). Other students indicated a preference for active learning, such as using clickers (“It really has started to help me a lot more than just sitting there listening because I physically have to be more involved in the lecture itself to understand the material”) or performing skits (“I really like how she saves the really complicated processes for the skits, and each one of us has a part and we remember each”)

Despite students’ positive attitudes toward active learning and their tendency to report that active-learning techniques were their “favorite” activities in class, many students still viewed passive techniques as more valuable for their learning. As shown in Figure 4, 58% of students taking a college biology course for the first time (n = 31) indicated that a passive technique (listening to lecture, looking at PowerPoint/visuals, or watching videos) was the most effective way to learn. Students who had taken a prior biology course were more apt to say that an active-learning technique (skits, clickers, group work, discussion, verbal questions, “activities”) was the most effective way to learn (63%, n = 24). Interestingly, only five students indicated that skits were the most effective way for them to learn, but 25 indicated that skits helped them “learn” or “understand” when explaining why that was their favorite activity in their open-ended responses.

Focus-group interviews provided some insight into why students (n = 8) had positive or negative attitudes toward specific types of active learning. Three students in one focus group talked about how verbal questioning keeps them engaged and makes them think about the material, even if they don’t answer the question. Many of the students discussed skits, indicating that they were helpful because it was easy to remember a classmate’s actions in the
Figure 4. Classification of activities that students enrolled in Cell Biology \((n = 55)\) reported as the most effective way to learn in Cell Biology lecture, as reported on an open-response survey administered at the end of the semester. Initial sub-categories were collapsed into active learning (including skits, clickers, group work, etc.), passive learning (including lecture, video, diagrams, etc) and other (including note-taking, studying outside of class, etc.). Some comments mentioned multiple activities and therefore were counted in multiple categories.

---

Discussion

Despite the push for science instructors to incorporate active-learning strategies into their classes, many science courses are still taught using traditional lectures (Brownell & Tanner, 2012; Vicens & Caspersen, 2014). Given that lectures, by their very nature, do not require much effort on the part of students, it is reasonable to think that students might resist the change from a traditional lecture format to a student-centered, active-learning format. There have been numerous reports of student resistance to various types of active learning used in STEM courses (Lake, 2001; Welsh, 2012; Bernot & Metzler, 2014). The results of this study indicate that students, including those who have previously experienced a traditional lecture biology course, generally have positive attitudes toward active learning.

At the institution where this study took place, some biology/biochemistry majors complete Organismal Biology prior to enrolling in Cell Biology, while others enroll in Cell Biology as their first biology course. Organismal Biology is taught in a traditional lecture format with very little interaction, while Cell Biology is taught using a combination of traditional lecture and active-learning pedagogies. Students generally perceived this difference, but it did not seem to influence their attitude toward active learning. When students were asked specifically about their attitudes toward various types of active and passive techniques that were used in Cell Biology, they generally expressed positive attitudes toward the active techniques regardless of their prior biology experiences. This was seen in both the Likert-scale survey that asked about a variety of specific techniques and in open-ended survey responses in which \(>80\%\) of students indicated that their favorite activity in Cell Biology lecture was some type of active learning. This is not to say that all students have positive attitudes toward active learning; in the open responses and focus groups, there were a few students who indicated that lecture or watching videos were their favorite activities. Some students also expressed negative perceptions of specific active-learning techniques or active learning in general.

A relatively small number of students who had completed a prior biology course responded to our questions regarding which course’s teaching methods they preferred \((n = 25)\), but the majority of those who did respond said that they preferred the teaching methods used in Cell Biology, and the majority of the students who preferred the methods used in Cell Biology said that it was because it was more engaging or hands-on. The small number of respondents and the possible confounding factors (instructor personality, class topic, influence from prior students, etc.) make it difficult to draw broad conclusions from these data, but it does seem to indicate that students appreciate pedagogical approaches that are more interactive than traditional lecture.

While students showed positive attitudes toward active-learning techniques, they were not as convinced of their learning benefits. While 81\% of students indicated that some type of active-learning technique was their favorite lecture activity, only 40\% indicated that an active-learning technique was the most effective way to learn in biology lecture. Interestingly, among students who had taken a prior biology course, 87\% indicated that their favorite classroom activity was an active-learning technique, and 63\% indicated that an active-learning technique was the best way to learn. It appears that students with more experience in learning biology had a greater understanding of the ability of active learning to help them understand or remember material. Although this study did not explore potential links between student perceptions of active learning and student performance, it would be interesting to determine whether those students who perceived a learning benefit from active-learning techniques were, in fact, retaining more information taught using that method than students who did not perceive the learning benefit.
Limitations of This Study

One limitation of this study is that the course that incorporated active-learning techniques was still using only a limited amount of active learning. The students seemed to appreciate having some interaction with their professor and peers, but this positive attitude might not carry over to a class that spent a larger proportion of time on active learning. Another limitation is that this study was carried out at a small, private liberal arts college, and the Cell Biology classes were relatively small (25–75 students). Student attitudes toward active learning might be different in a larger classroom setting. The small class size also means that the sample size was small, which limits the power of statistical analysis. In addition, the fact that prior biology courses taken by students had different instructors than the Cell Biology course means that their opinions on both active and passive pedagogies may have been influenced by their instructors’ personality and method of implementing any given technique.

Conclusion

Extensive research has shown that active learning improves student performance in STEM courses (Freeman et al., 2014), and numerous national initiatives have been launched to increase the amount of active learning used in STEM classrooms (e.g., National Science Foundation, 2013; AAAS, 2015). Despite this push for change, many instructors are hesitant to incorporate active learning into their courses, with some citing concerns about student attitudes toward nontraditional pedagogies (Michael, 2007; Froyd et al., 2012; Prince et al., 2013; Lund & Stains, 2015). It was hypothesized that students who had a traditional lecture in their first college biology course would have more negative attitudes toward active learning in a subsequent course than students that experienced active learning in their first biology course. The data gathered in this study did not support the hypothesis, and in fact seemed to indicate that students who experienced a traditional, lecture-style biology course first had more positive attitudes toward active learning in a subsequent biology course than students that experienced active learning in their first biology course. This suggests that instructors can incorporate small amounts of active learning into their classes without fear of student revolt, even if it might be the student’s first exposure to the use of active learning in a biology course.

Acknowledgments

I thank my colleagues in the Biology Scholars Program Research Residency for their assistance with designing this project, Dr. Elisabeth Schussler for her guidance, Dr. Benjamin England for assistance with data analysis, and Dr. Jerilyn Swann for assistance with implementing the project.

References


JENNIfer BRIGATI is an Associate Professor of Biology in the Division of Natural Sciences at Maryville College, 108 Sutton Science Center, 502 E. Lamar Alexander Pkwy, Maryville, TN 37804-5919; email: Jennifer.brigati@maryvillecollege.edu.

“The hands on experience with preserved specimens have inspired several of my students to go into the world as doctors and nurses.”

Bernie R.

www.biologyproducts.com