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ARTICLE
Don't Believe the Gripe! Increasing Course Structure in a Large Non-majors Neuroscience Course

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Active teaching is increasingly accepted as a better option for higher education STEM courses than traditional lecture-based instruction. However, concerns remain regarding student preferences and the impact of increased course structure on teaching evaluations. Undergraduates in a non-majors neuropharmacology course were enrolled in an enriched blended course format, providing online case-based learning opportunities in a large lecture hall setting. Students working in small assigned groups solved weekly case studies developed to teach basic neuropharmacology concepts. All case study assignments were peer reviewed and content was further reinforced with a weekly online quiz. A comparison of scores on equivalent midterm and final exam questions revealed that students enrolled in the High-Structure course scored better than students from the previous year that took a more traditional Low-Structure lecture-based course. Student performance increased significantly for exam questions that required Bloom's level understanding. When surveyed, students in the High-Structure course reported some regret for the lack of traditional lecture and revealed some disapproval towards the extra work required for active teaching and peer review. Yet, we saw no change in quantitative instructor evaluation between sections, challenging the idea that student resistance towards increased work lowers course evaluation scores. Future instructors using active learning strategies may benefit from revealing to students the value of increased course structure on performance outcomes compared with traditional lecture courses.

Key words: non-majors neuroscience education, case study active teaching, neuropharmacology, Science, technology, engineering, and mathematics (STEM), remote learning, peer reviewed group work, hybrid, blended

The Society for Neuroscience (SFN) has a global mission to increase its role in public education. SFN's Public Communication Committee was formed to establish priorities aimed at increasing literacy and enhancing the visibility of the neurosciences in both public and academic communities. One way that universities might share this vision is through a more careful design of non-majors neuroscience courses that fulfill general education (GE) requirements for higher education students (Stevens, 2011).

All college level biology courses, including those that fulfill GE requirements should strive to achieve student core competencies for college-level biology proposed by the National Science Foundation (NSF), the Howard Hughes Medical Institute (HHMI), the National Institutes of Health (NIH) and the American Association for the Advancement of Science (AAAS) as stated in the Vision and change in undergraduate biology education: a call to action. These competencies include: 1) the ability to apply the process of science; 2) the ability to use quantitative reasoning; 3) the ability to use modeling and simulation; 4) the ability to tap into the interdisciplinary nature of science; 5) the ability to communicate and collaborate with other disciplines; and 6) the ability to understand relationships between science and society" (Brewer and Smith, 2011).

Introductory level neuroscience GE courses share common challenges across all STEM fields, including wide-ranging demographics and differing degrees of student preparedness. The utilization of best teaching practices defined by discipline-based education research consistently reveals increased student learning gains and greater student performance on assessments in higher education courses, especially for those students that are traditionally underrepresented in STEM (Ledbetter, 2012).

The degree of course structure can make a difference for Neuroscience GE students from backgrounds underrepresented in STEM fields. Highly structured introductory courses that incorporate daily practice with problem-solving, data analysis, and other higher-order cognitive skills can reduce the gap created by different levels of incoming student preparation (Freeman et al., 2011). A highly structured course design provides the greatest benefit for underrepresented populations, reducing the risk of failure for students who are less prepared than their peers (Freeman et al., 2011). Meta analysis of data on application of active teaching strategies in classrooms reveals that active learning improves student exam scores and reduces overall failure rates in introductory level biology courses (Freeman et al., 2014).

Instructors can transform large low-structure GE lectures into active learning opportunities by utilizing "learn before lecture" assignments online that include case studies, quizzes, peer review and videos designed to engage students with interactive exercises (Smith et al., 2009; Wood, 2009; Moravec et al., 2010; Casotti et al., 2013; Herreid and Schiller, 2013; Wiertelak et al., 2016). This type of instruction provides a collective educational experience that affords more instruction time and learning gains that cannot be solely attributed to increased time on task (Means et al., 2009).

Grade motivation has been shown to increase the effectiveness of active teaching strategies, encouraging students to complete assignments for points. Comparisons of a variety of active teaching approaches revealed that the greatest performance improvement occurs when students receive more repetition and practice, and complete regularly assigned exercises for credit (Freeman et al., 2007; McKenzie et al., 2013). Follow up studies showed that points allotted for active-learning assignments do not artificially inflate final grades or diminish the impact of exam scores on final grades (Freeman et al., 2011).

The use of case-based activities provides opportunities to teach neuroscience concepts while making course content directly applicable to problem-based situations that interest students (Stevens, 2011; Casotti et al., 2013; Herreid and Schiller, 2013; Wiertelak et al., 2016; Roesch and Frenzel K, 2016. In an online survey conducted by the National Center for Case Study Teaching in Science, 200 instructors acknowledged that they had applied active teaching strategies in their courses, the majority reporting that these activities promoted thinking both inside and outside the classroom and that students became more actively involved in the learning process (Yadav et al., 2007). Instructors that have adopted blended course structures benefit from increased time spent on active teaching and course structure, affording several advantages over passive lecture-based courses. These benefits include more effective use of classroom time as well as greater student achievement and engagement (Yadav et al., 2007; Fulton, 2012).

Despite the evidence, there is still opposition to the active teaching revolution in undergraduate science education (DeHaan, 2005; Gormally et al., 2014). Obstacles commonly cited include the practicality of grading and evaluating student work, especially in large lecture courses, and having to sacrifice course content to accommodate activities that are time consuming to develop (Herreid and Schiller, 2013; Gormally et al., 2014). Instructors using case-based active teaching report that students are "initially resistant" to doing work on their own before being exposed to the relevant content in class (Herreid and Schiller, 2013). The thought of increasing student workload in a large GE course can be intimidating for instructors, especially those that are promoted based on student evaluations (Gormally et al., 2014).

This paper investigates the transformation of a large Low-Structure introductory GE neuroscience course (Drugs & the Brain) to an enriched High-Structure course aligned with discipline-based education research (Wood, 2009; Ledbetter, 2012; Singer et al., 2012). Students in the High-Structure course were provided active learning opportunities that included group work, case-based learning, peer review and online quizzes. We then investigated the impact of increased course structure on student performance, student opinions about the course format and student evaluations of teaching.

MATERIALS AND METHODS

Two non-majors neuroscience GE classes were compared; one given in the fall of 2014 (n = 281 students) and the other in the fall of 2015 (n = 193). Students were enrolled randomly into the course sections. Both classes were taught by the same Assistant Teaching Professor, Andrea Nicholas. Student participation in the research was strictly voluntary and students were informed that opting out of the study would have no impact on their course assignments or grade. Student choice to opt out of the study was anonymous until final grades were made official. As such, only one student in the High-Structure 2015 class chose not to participate in the study.

The Low-Structure 2014 course met twice per week for 80 minutes and employed traditional teaching methods that included projected slide lectures and think, pair, share discussion moments among students. During think, pair, share, the lecturer posed a thought question to the lecture hall and asked students to discuss it with classmates sitting near them. The students, as a whole, were then asked to voluntarily share what their groups had considered or concluded.

The High-Structure 2015 course also met twice per week for 80 minutes. Students were randomly assigned groups of 4-6 before the beginning of the course. During the first class of each week, students sat with their assigned groups and worked on in-class case studies that paired with weekly readings from their course textbook (Grilly and Salamone, 2011). Students were encouraged to use their textbook to solve the directed case studies, but were not prevented from using alternative online sources. While students worked in class, the instructor navigated the lecture hall assisting groups. Each group submitted a completed case study assignment through the online platform Canvas prior to the following class (https://www.instructure.com).

The class following each case study deadline consisted of an interactive lecture session led by the instructor. During this session, the instructor reviewed solutions for case studies with the class as a whole, discussing any misconceptions or questions students might have. Following the lecture session, students were asked to peer-review three of their fellow students' case study submissions and provide a grade.

The Canvas platform can randomly assign multiple online peer reviews to each enrolled student. All students were provided a rubric within Canvas for scoring their peers' case study submissions. In addition to providing a quantitative score, students were asked to provide written comments, explaining their grading decisions. Our peer review process thus provided each group an averaged quantitative grade as well as detailed feedback. Peer review also ensured that each student actively reinforced the course material covered each week by carefully grading three assignments.

An online quiz of 6-8 multiple choice questions was made available to students upon completion of three peer reviews, providing additional incentive. Students who did not complete their peer reviews were not allowed to access the online quiz and therefore lost the associated points. Canvas was used to organize the delivery of online case study assignments, peer review scoring, written feedback and conditional access to online quizzing.

Case Studies:
The directed case studies assigned for the High-Structure course were devised to cover the same content that had been presented in the Low-Structure course lectures. A total of seven sets of directed case studies were used to focus on different drug classes (Cocaine, Amphetamine, Antipsychotics, Antidepressants, Anxiolytics, Opiates and Hallucinogens) were assigned over the quarter. Each case study consisted of 13 mini-cases that each highlighted a basic neurophysiology or pharmacology concept, including the following: action potential, neurotransmitter synthesis and release, agonists and antagonists, receptor subtypes, behavioral paradigms, binding graphs, dose-response graphs, drug delivery and metabolism, neural circuitry, addiction and withdrawal, receptor regulation, tolerance and sensitization. Case studies were written with intent to foster previously developed core competencies in neuroscience students (Kerchner et al., 2012). For further details on the case studies used, please see the article, *Drugs & the Brain: Case-based instruction for an undergraduate neuropharmacology course*, in this issue of *JUNE* (Nagel and Nicholas, 2017).

Assessment:
Both the Low-Structure (2014) and High-Structure (2015) course sections received two Midterm exams and one comprehensive Final exam comprised of approximately 25 multiple-choice questions. A total of 19 equivalent (the same question with a slight change in values for graphs or answer order) from the 2014 exam were embedded within the 2015 exams to assess student performance. The exams and keys from 2014 were not accessible to 2015 students. Scores on these questions were used to assess the performance of students in the enriched hybrid course compared to the traditional lecture course.

We categorized each of the test questions using Bloom's taxonomy (Bloom et al., 1956; Crowe et al., 2008). Because the course was traditionally a large introductory level non-majors neuroscience course that utilized multiple-choice questions, the comparable test questions fell into the first three levels of Bloom's taxonomy, including *Remembering*, *Understanding* and *Application*. There was a total of 7 *Remembering, 7 Understanding* and 5 *Application* questions.

Examples of test questions:

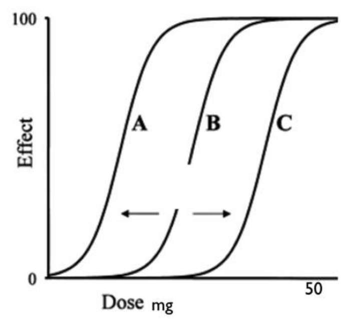
Example A. *Remembering:* Below is an example of a question that required the student to recall relevant knowledge from long-term memory.

Threshold is defined as a membrane voltage at which an action potential is initiated by:
a. Many Na+ voltage-gated channels opening, allowing sodium ions out of the cell
b. Many K+ voltage-gated channels opening, allowing sodium ions out of the cell
c. Many Na+ voltage-gated channels opening, allowing sodium ions into the cell
d. Many K+ voltage-gated channels opening, allowing potassium ions out of the cell
e. Many K+ voltage-gated channels opening, allowing potassium ions into the cell

Example B. *Understanding*: Below is an example of a question that required a student to remember a given receptor's activity and also to understand the connection between receptor activation and subsequent downstream events.

Opioid receptors are ________________ that ________________GABA activity in the VTA, thereby ________________ dopamine release.
a. Ion channels, increase, increasing
b. Ion channels, inhibit, inhibiting
c. Metabotropic receptors, increase, inhibiting
d. Metabotropic receptors, inhibit, increasing

Example C. *Applying:* Below is an example of a question that required a student to understand the meaning of tolerance and also apply that knowledge while interpreting a dose-response graph. A dose-response graph can only provide information on the amount of drug administered and the analgesic response, but not addiction. Some drugs cause tolerance, but do not result in addiction.



The above dose-response curve labeled B represents a painkiller medication that Susanne started taking last January. The drug worked quite well at first, but Susanne started having breakthrough pain, so her doctor had to increase the dose. This is an example of:
a. Sensitization, best illustrated by the leftward shift from B to A
b. Tolerance, best illustrated by the rightward shift from B to C
c. Sensitization, best illustrated by the rightward shift from B to C
d. Tolerance, best illustrated by the leftward shift from B to A
e. Addiction, best illustrated by the rightward shift from B to C

Course Survey:
At the end of the quarter, the instructor provided students in the High-Structure section with an online survey to assess their opinions about the active teaching strategies used in the course.

Teaching Evaluation:
Students voluntarily provided quantitative and qualitative

evaluations of course instruction through an online teaching evaluation survey that is automatically launched at the end of each course by the university.

Statistics:
The statistics software, STATA was used to run mixed effects linear regression analysis with a random effects variable for student ID, given that each student answered more than one question. Survey data of students from the enriched class is summarized as the proportion of student response. A total of 171 out of a possible 198 students participated in the survey.

RESULTS & DISCUSSION

Table 1.
Overall effect of Exam Order and Increased Course Structure on Combined Mean Exam Scores for both 2014 and 2015 Classes

Mean Score	***B*** **(*SE*)**	**[95% Conf. Interval]**	
Increased Course Structure	0.034* (0.015)	0.004	0.064
Exam Sequence	0.041*** (0.007)	0.027	0.056

Table 1. The above represents a linear mixed effects regression with a random effects variable for Student Identity. Results show the Beta coefficient (*B*), Standard Error of the Beta (*SE*), and p value (*). The Beta (*B*) coefficient represents the regression line relationship between the dependent and independent variables. Independent Variables: Exam Sequence (Midterm 1, Midterm 2 and Final) and *Increased Course Structure*. Dependent Variable: Mean score on test questions. *p <0.05 **p<0.01 ***p<0.001.

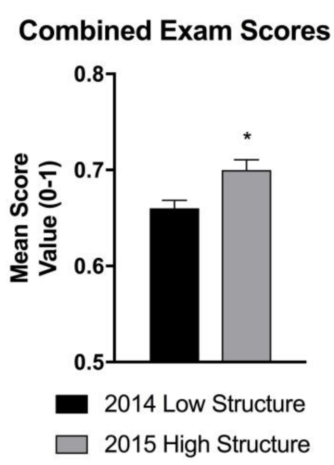


Figure 1. The above graph compares Mean Score + SE for combined Midterm 1, 2 and Final exam question from the 2014 (low-structure) and 2015 (high-structure) courses. *p <0.05.

Overall Mean Scores were greater for students enrolled in a High Structure Neurobiology Course. A large body of research suggests that students perform better in active teaching classes with increased course structure compared to traditional lectures, with an average overall improvement of 6% (Freeman et al., 2007; Yadav et al., 2007; Means et al., 2009; Freeman et al., 2011; Fulton, 2012; McKenzie et al., 2013). Our initial findings revealed a significant positive correlation between *Increased Course Structure* and *Mean Score* (Table 1) that is in keeping with previous findings showing that increased course structure leads to performance gains on assessments (Freeman et al., 2014). The combined mean exam score for students in our high-structure blended class was significantly better than those in the low structure traditional lecture course (Fig. 1). This gain, though significant, is expected to be moderate given the large class size since the greatest gains are seen in classes that are less than 50 students (Freeman et al., 2014).

Mean Scores for students in both the Low-Structure course and High-Structure course increased over time. Overall, *Mean Score* increased in relation to *Exam Sequence*, demonstrating a general performance improvement over the quarter (Table 1). The significant increase in performance from Midterm 1 to the Final Exam was observed for both Low (*B=0*.04, SE=0.01, p < 0.001***) and High-Structure courses (*B=0*.04, SE=0.01, p < 0.001***).

This type of overall improvement in Mean Score over time is not uncommon for large classes and may represent both familiarity with exam format and decreased test-taking anxiety with repeated exam exposure. Similar findings suggest that students expected to "learn before lecture" perform better on sequential exams, but scored similarly to students taught in a traditional lecture format on the final exam (Love et al., 2014). It is therefore critical to compare student performance over time for both instruction formats as the course progressed.

Table 2.
Influence of Increased Course Structure on Mean Score, split by Exam Sequence

Mean Score	***B*** **(*SE*)**	**[95% Conf. Interval]**	
Midterm 1	0.06* (.024)	0.008	0.102
Midterm 2	-0.01 (0.026)	-0.065	0.038
Final Exam	0.06*** (0.016)	0.025	0.088

Table 2. The above data represents a linear mixed effects regression split by *Exam Sequence* with a random effects variable for Student Identity. Results show the Beta coefficient *(B)*, Standard Error of the Beta *(SE)*, and p value (*). The *Beta (B) coefficient represents the regression line relationship between the dependent and independent variables.* Independent Variables: *Increased Course Structure*. Dependent Variable: *Mean Score* on test questions relevant to each exam. *p <0.05, ***p<0.001.

Students in the High-Structure course performed better on Midterm 1 and the Final exam, but not Midterm 2. Data revealed a significant positive correlation between *Increased Course Structure* and *Mean Score* for Midterm 1 and the Final Exam, but not for Midterm 2 (Table 2, Fig. 2). Midterm 2 contained a greater number of Bloom's Level *Application* questions, thus potentially posing a greater challenge for students. Thus, the observed overall increase in performance observed for the High-structure course is due to Midterm 1 and the Final Exam.

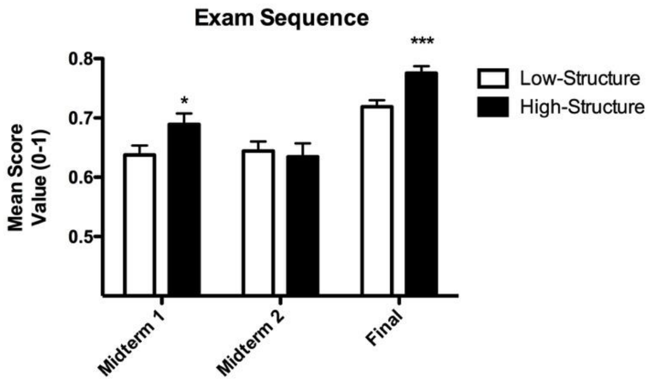


Figure 2. The above graph represents Mean Score + SE on exams from the 2014 (low-structure) and 2015 (high-structure) courses. Individual exam questions were scored on a 0-1 scale (correct = 1, incorrect = 0). *p <0.05, **p<0.01,***p<0.001.

Table 3.			
Influence of Increased Course Structure on Mean Score, split by Bloom's Categories			
Mean Score	***B*** **(*SE*)**	**[95% Conf. Interval]**	
Remembering	0.004 (.017)	-0.030	0.038
Understanding	-0.116*** (0.019)	0.080	0.153
Application	-0.003 (0.022)	-0.047	0.041

Table 3. The above data represents a linear mixed effects regression, split by Bloom's categories: *Remembering, Understanding* & *Application*, with a random effects variable for Student Identity. Independent Variables: *Increased Course Structure*. Dependent Variable: *Mean Score* on test questions. ***p<0.001.

The greatest improvement in student performance in the High-Structure course was observed for questions categorized as Bloom's Level 2: *Understanding*. *Increased Course Structure* was associated with improved *Mean Score* on questions categorized as *Understanding* (Bloom's level 2)*, but not Remembering* or *Application* (Blooms level 1 & 3 respectively) (Table 3). This indicated that case study assignments, peer review and quizzes targeted improvement of content comprehension.

To better demonstrate this effect, we show Mean Scores for each test question individually (Fig. 3). Improved *Mean Score* as a result of *Increased Course Structure* was observed for only 1 of 7 test questions categorized as *Remembering* (Fig. 3, A.). This question asked students to recall which ion channels opened during the rising phase of action potential. A decrease in Mean Score for students in the High-Structure course (2015) was observed for two recall questions, one that asked students to identify a drug used to treat heroin withdrawal (Q#3) and another to identify drugs that did not have any validated withdrawal symptoms (Q#7). It is possible that the practice of researching detailed information for the case studies diminished the importance of fact memorization.

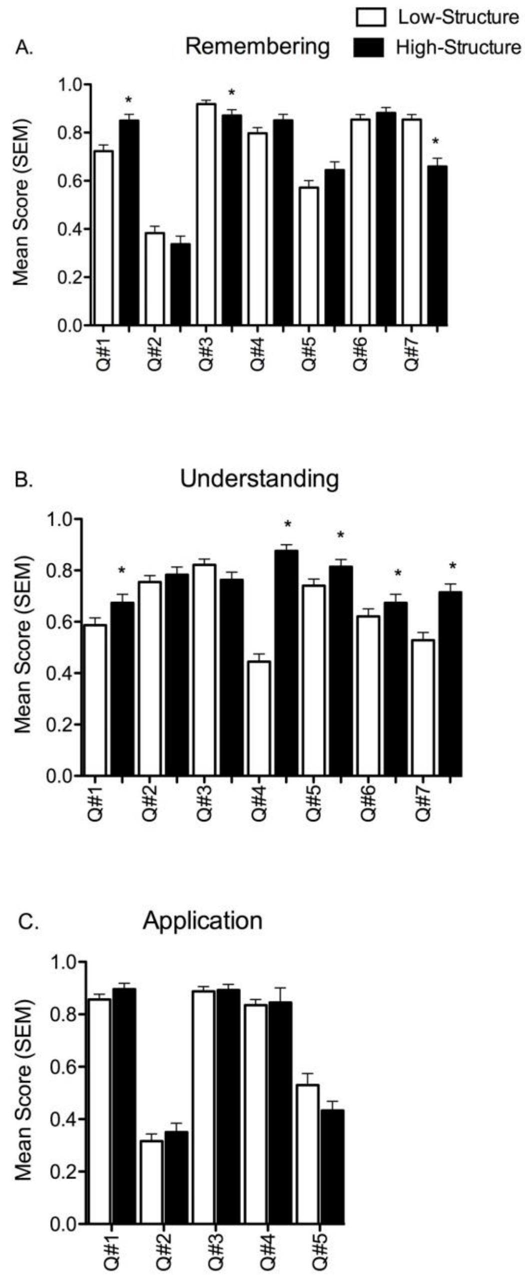


Figure 3. *p <0.05, **p<0.01,***p<0.001. The above graphs represent t-test comparison of scores on equivalent test questions given to the Low-Structure and High Structure courses. Test questions were sorted into Bloom's Levels A) *Remembering*, B) *Understanding* and C) *Application*. Dependent Variable: Raw score on individual test questions. Individual exam questions were scored on a 0-1 scale (correct = 1, incorrect = 0). *p <0.05, **p<0.01,***p<0.001.

Table 4.

Quantitative survey data on student opinions about the structured course.

I have had a chance to experience a traditional lecture course that did not incorporate any active teaching methods.	Yes		No	
	0.83		0.16	
In hindsight, would you have signed up to take this course?	Yes	Don't Know		No
	0.64	0.16		0.20
Which of the following was the most enjoyable part of this course?	Lecture session	Group work	Peer review	Quizzes
	0.54	0.29	0.05	0.12
Which of the following was most effective in terms of learning course content?	Lecture session	Group work	Peer review	Quizzes
	0.57	0.19	0.04	0.2
I prefer a course that only has a midterm and final exam to a course with quizzes and assignments.	Agree	Neither Agree nor Disagree		Disagree
	0.59	0.29		0.12
I would recommend an active teaching course like Bio Sci 36 to a peer.	Agree	Neither Agree nor Disagree		Disagree
	0.48	0.33		0.18

Table 4. The above data represent the proportion of students responding for each question.

Increased Mean Scores for students in the High-Structure course was observed on 5 out of 7 questions requiring Bloom's Level *Understanding*, demonstrating a strong benefit of case-based active learning for this category (Fig. 3, B: Q#1; 4,5,6,7). *Understanding* questions required students to know the mechanism of action for drugs in the synapse, requiring students to draw conclusions about the effects of a drug based on its known function.

There was no observed impact of increased course structure on Bloom's Level *Application* questions. This was true for questions students scored well (Fig. 3, C: Q#1; 3,4) and poorly (Fig. 3, C: Q#2 & 5) on, suggesting that the lack of effect was not due to a general increase in Bloom's Level complexity. Application questions required students to interpret dose-response curves in order to solve a case-based question. Students were asked to make determinations about specific drugs based on potency and efficacy values derived from provided graphs. Interestingly, a high percentage of the active learning case studies in the High-Structure course targeted this level of understanding, yet no improvement over the Low-Structured course was observed. Application level questions measure more than learned information and by make-up, incorporate mean student aptitude for creative thinking and problem solving. While case studies provided ample practice for these processes, the likelihood of achieving a measurable benefit in a quarter-long class might not have been achievable. This supports the notion that, in order to have greater impact, active teaching and increased structure should be adopted across a higher education curriculum.

While it is possible that there may be an ideal level for performance gains in large lecture halls applying active learning strategies, we have to consider the probability that our total performance gains were moderate in general because of the large class size. Although active learning positively influences student test scores across all STEM disciplines and class sizes, the greatest influence occurs in classes with fewer than 50 students, reaffirming findings that instructor awareness of individual student learning and availability to spend adequate one on one time is a major component of active teaching success (Freeman et al., 2014). If our course size was smaller, allowing for an increase in personal interaction between the instructor and each individual student for every case study, we might have seen gains in higher order questions requiring *Application* as well.

Student opinions favored Low-Structure traditional teaching. A majority of students stated that they would still have taken the High-Structure course in hindsight and would recommend an active teaching course to a peer, suggesting that they did not expressly dislike exposure to active learning (Table 4). The High-Structure course was focused on group work and peer review, but more students identified the lecture session as the most effective way to learn and online quizzes as being the second most useful (Table 4). Students also found the lecture sessions to be more enjoyable, with group work being the second most enjoyable part of the course. Further, the majority of students indicated that they would prefer a more traditional course format that only had one midterm and a final to a course with quizzes and assignments (Table 4).

Students' opinions about how they learn do not accurately reflect course instruction. There was a higher percentage of students filling out course evaluations for the High-Structure course (67%) relative to the Low-Structure course (43%) (Table 5). As the course evaluations were entirely voluntary and not required, large lecture courses typically show reduced response rates. Response rate itself doesn't tell much about quality of teaching, but it may suggest something about student investment in the course or a need to provide input (Stark and Freishtat, 2014). There were no significant differences in mean quantitative evaluations for the instructor despite the very different course instruction formats, suggesting that student evaluations were not influenced by increased work or degree of course structure (Table 5). These findings are supported by a body of literature showing that student evaluations are, at best, tenuously linked to teaching quality and are better predictors of instructor attractiveness, friendliness, gender, ethnicity and age (Stark and Freishtat, 2014).

Table 5.

Comparison of student teaching evaluations

Teaching Evaluation Score	*Low-Structured Course (n=128/300, 42%)*	*High-Structured Course (n=132/198, 67%)*
The course instructor shows enthusiasm for and is interested in the subject.	3.76 Mean	3.69 Mean
	4.00 Median	4.00 Median
	0.52 SD	0.57 SD
The course instructor stimulates your interest in the subject.	3.32 Mean	3.39 Mean
	3.70 Median	3.70 Median
	0.89 SD	0.80 SD
The course instructor meets stated objectives of the course.	3.59 Mean	3.54 Mean
	4.00 Median	3.70 Median
	0.65 SD	0.71 SD
The course instructor is accessible and responsive.	3.49 Mean	3.55 Mean
	3.70 Median	4.00 Median
	0.69 SD	0.68 SD
The course instructor creates an open and fair learning environment.	3.59 Mean	3.55 Mean
	4.00 Median	4.00 Median
	0.65 SD	0.71 SD
The course instructor encourages students to think in this course.	3.59 Mean	3.61 Mean
	4.00 Median	4.00 Median
	0.65 SD	0.60 SD
The course instructor's presentations and explanations of concepts were clear.	3.17 Mean	3.20 Mean
	3.30 Median	3.30 Median
	0.91 SD	0.94 SD
Assignments and exams covered important aspects of the course.	3.37 Mean	3.47 Mean
	3.70 Median	3.70 Median
	0.82 SD	0.70 SD
What overall grade would you give this instructor?	3.41 Mean	3.38 Mean
	3.70 Median	3.70 Median
	0.72 SD	0.81 SD
What overall grade would you give this course?	3.29 Mean	3.14 Mean
	3.30 Median	3.30 Median
	0.72 SD	0.82 SD

Table 5. The above data represent Mean, Median and SD on a 4-point scale with 4 being high.

Teaching evaluations also asked students to provide written suggestions about ways instruction could be improved for the course in the future. For the Low-Structure course 73% of respondents offered suggestions for instructional improvement. Only 16% of those statements expressly asked for increased course structure of some kind, including quizzes, worksheets, homework, examples, online supplements and textbook assignments. These suggestions are typical of students in courses that are looking for additional ways to earn points.

Student responses:

- *"I would give out homework so that students like me can understand the material better."*
- *"Assign short take home quizzes."*
- *"She could apply different methods of teaching."*
- *"The instructor can improve as a teacher if she made it more clear exactly what points to emphasize on when we're studying to know what we would be heavily tested on since there was so much information each lecture."*

The remaining suggestions for improving the Low-Structure course addressed the lecturer's speaking pace and volume, lecture content and exam questions.

Student responses:

- *"Speak louder (the microphone is so far away from her mouth)."*
- *"She goes through material very fast and sometimes not good into depth."*
- *"Speak slower; sometimes I have a hard time writing things down because she moves a little fast."*

Students were also asked to comment on the instructor's strengths. For the Low-Structure course, 83% of evaluation respondents provided positive comments regarding the instructor's lecturing style.

Student responses:

- *"Was great in explaining concepts thoroughly and giving real-life examples of these."*
- *"Has a sense of humor and she tends to tightrope this into her lectures, thus making the lecture a lot more interesting."*
- *"She is enthusiastic about neurobiology, and she makes lectures interesting."*

For the high-structured course, 78% of respondents offered suggestions to improve instruction. Of those responses, 68% recommended that case study groups should be replaced with traditional lectures or that the instructors increase the total time spent lecturing.

Student responses:

- *"Could improve her teaching strategy by re-implementing PowerPoint lessons and relying less on active learning."*
- *"I think a more traditional presentation style would have been more effective, given that a big part of the class consisted of group work."*
- *"She could do standard lecture teaching rather than give us a case study and have us teach ourselves."*

Positive comments were offered by 87% of respondents. The majority of the positive comments focused on the instructor's enthusiasm, ability to explain concepts and answer student questions.

Student responses:

- *"She is very thorough with her explanations and she will explain in multiple ways to ensure someone understands."*
- *"Very enthusiastic professor! Case studies were interesting."*
- *"Taking complicated information and making it accessible to those who are not bio majors. Very funny stories and analogies."*

It is widely accepted that active teaching improves performance, but students may resist new teaching techniques (Herreid and Schiller, 2013). Further, student-centered activities can lead to concerns about instructor expectations and involvement, including how assignments will be graded, unbalanced delegation of work in groups or how much peer interaction is enough. For this reason, instructors may choose to refrain from implementing active techniques vetted by discipline-based education research out of concern for poor teaching evaluations. We report no change in quantitative teaching evaluation scores despite a substantial increase in course structure, further demonstrating the unreliability of student evaluations as indicators of quality instruction. A more genuine reflection of student attitudes was gained from written suggestions for course improvement, revealing some opposition to the increased workload of active teaching compared to traditional lecture. However, the same respondents also offered positive comments suggesting that the case studies were interesting, entertaining and informative.

It has been proposed that a blended or hybrid style course may offer the best approach to this type of resistance, providing a combination of lecture and active teaching (Walker et al., 2008). Our surveys revealed that even in a highly structured blended course format, a high percentage of students will still believe that they learn more from lecture, while their performance shows otherwise. Thus, institutions should concern themselves less with student evaluations and more with instructor effort to increase course structure and provide real evidence of student learning in their courses that is grounded in discipline-based education research. Instructors of large GE neuroscience courses seeking to implement best teaching practices can inform students about the potential learning gains afforded by active teaching, thereby diffusing resistance. The way forward is dependent on motivated instructors willing to put in the extra time and work required to devise quality active teaching courses. The ever-growing body of available online materials, including published case studies, course goals, learning outcomes, rubrics, vetted assessments and online technologies like Canvas collectively provide a practical transition toward, and a more legitimate evaluation of better instructor teaching and student learning.

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