Working title: C.R.E.A.T.E'ing shifts in first year students' science efficacy that are independent of instructor rank and experience in a large, multi-section online introductory course

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Take home message: Novice C.R.E.A.T.E instructors successfully shift first year student's science efficacy in an introductory biology course independent of teaching experience.

Abstract:
While the remote working and learning environment overwhelmed instructors of all courses throughout the COVID-19 pandemic, it presented an especially unique challenge to instructors of laboratory courses designed to engage students through a "hands-on" curriculum. With a primary objective to engage students in the process of science throughout the COVID19 pandemic, we transformed a long-standing laboratory course for first year science students into a more accessible, immersive experience of current biological research using a narrow and focused set of primary literature and the C.R.E.A.T.E pedagogy. The efficacy of the C.R.E.A.T.E approach has been demonstrated in a diversity of higher education settings and courses. It is however not yet known if C.R.E.A.T.E can be successfully implemented online with a large, diverse team of faculty untrained in the pedagogy. Here we present the transformation of a large-enrollment, multi-section, multi-instructor course for first-year students in which instructors are following different biological research questions but working together to reach shared goals and outcomes. We used a mixed-methods approach to collect data and assess students': (1) science self-efficacy and (2) epistemological beliefs about science throughout an academic year that was fully administered online as a result of ongoing threats posed by the COVID19 pandemic. Our findings demonstrate that novice C.R.E.A.T.E instructors with varying levels of teaching experience and ranks (research faculty, teaching faculty, and postdoctoral research fellows) can achieve comparable outcomes and improvements in students' science efficacy in the virtual classroom as a teaching team. This study extends the use of the C.R.E.A.T.E strategy to large, team-taught, multi-section courses and shows its utility in the online teaching and learning environment.

Introduction:
The COVID-19 pandemic forced an unprecedented shift to online learning in higher education (Farnell et al. 2021). The rapid transition to "emergency remote teaching (ERT)" challenged instructors of in-person classes, many of whom were untrained and inexperienced in online teaching practices, across campuses around the world (Hodges et al. 2021). While ERT characterized the instructor experience in the Spring of 2020, many colleges and universities continued to deliver courses online into the Fall of 2020 and some courses remained online even in the Fall of 2021 or were forced to go back online despite an initial return to in-person classes (Elias et al. 2020). While the remote working and learning environment has overwhelmed instructors of all courses traditionally taught on campus, it presented an especially unique challenge to instructors of laboratory courses designed to engage students in the process of science through a "hands-on" curriculum (Gamage et al. 2020).

Laboratory courses give students access to the tools, equipment, and technology involved in discovery and are therefore an integral part of science education (Hofstein and Lunetta 2004; Bretz 2019).

Students get the opportunity to participate in the process of science, cultivate problem-solving and critical thinking skills, enhance their ability to understand practical problems, and improve their attitude towards learning (Lunetta and Tamir 1978). During the COVID-19 pandemic, science instructors were forced to rethink and creatively redesign laboratory courses to effectively reach these learning outcomes in remote learning environments.

The **C**onsider, **R**ead, **E**lucidate a hypothesis, **A**nalyze and interpret data, **T**hink of the next **E**xperiment (C.R.E.A.T.E) strategy focuses on scientific thinking. C.R.E.A.T.E uses a novel selection of readings and gives students a chance to engage deeply in activities characteristic of actual science practice (Gottesman and Hoskins 2013). In C.R.E.A.T.E courses, faculty and students apply a suite of evidence-based techniques (e.g. concept mapping, cartooning experiments) in deconstructing and analyzing scientific primary literature. Students learn how to build upon content knowledge and develop the ability to think deeply and critically about the methods and results of scientific studies (Hoskins and Krufka 2015; Hoskins et al. 2017; Kenyon et al. 2019a). The strategy aims to help students experience the authentic practices of scientists, recognize the limitations of studies as well as the creativity and open-ended nature of science, and challenge their beliefs about what it means to be a scientist. C.R.E.A.T.E allows students to acquire many of the skills traditionally taught in a laboratory setting yet makes participation in the practice of science more affordable, adaptable, and accessible. The student-centered activities that define the C.R.E.A.T.E approach such as concept mapping content, cartooning studies, annotating and transforming data, elucidating hypotheses, and designing experiments are all conducive to learning online making the pedagogy a good fit for different learning environments.

The C.R.E.A.T.E strategy has been introduced and tested at several institutions and studied between two year and four-year institutions in both introductory and upper-level courses by individual faculty members (Hoskins et al. 2011a; Gottesman and Hoskins 2013; Stevens and Hoskins 2014; Kenyon et al. 2016, 2019a; Pugh-Bernard and Kenyon 2020a). These studies demonstrate the efficacy of the C.R.E.A.T.E approach in a diversity of higher education settings and courses. It is however not yet known if C.R.E.A.T.E can be successfully implemented online with a large, diverse team of faculty untrained in the pedagogy. At the University of British Columbia (Canada), we redesigned a first-year biology laboratory course for a large-enrollment, multi-section, multi-instructor course for the virtual classroom based on the C.R.E.A.T.E pedagogy where instructors were following different biological research questions but working together to reach shared goals and outcomes.

The diversity of teaching experience, research backgrounds, and instructor ranks across the teaching team raised the question of instructor-specific effects on student outcomes. To explore the question of whether an instructor's degree of teaching experience, research background, and role at the university influenced student outcomes we grouped instructors of the same rank and title (Research Professor, Research Associate Professor, Associate Professor of Teaching, Assistant Professor of Teaching, Lecturer, Sessional Instructor, and Postdoctoral Research Fellow) and compared student outcomes. In this study we show that novice C.R.E.A.T.E instructors with varying levels of teaching experience and ranks (i.e., research faculty, teaching faculty, and postdoctoral research fellows) can achieve comparable outcomes in the affective domain of learning in the virtual classroom when working together as a teaching team.

Methods

Context

Participants in this study were undergraduate students at the University of British Columbia in Canada, a large, public, research-intensive university, who enrolled in a term-long "Biology 140: Laboratory Investigations in Life Sciences" course during the winter and spring term 2020. In total 1,282 students enrolled during both terms (T1: 563 students, T2: 719 students) were distributed over 52 sections with 25-28 students per section. In total, seven different types of instructors taught a varying number of sections: Research Professors (10), Lecturers (2), Associate Research Professors (2), Assistant Professors of Teaching (1), Associate Professors of Teaching (2), Sessional Instructors (2), and Postdoctoral Research Fellows (3). In each term, at the first day of the course, students were invited to participate in a survey on a voluntary basis (with no bearing on class grade) asking about their self-assessed ability to read, analyze, understand, and use a diversity of scientific skills. The same survey was distributed to the students on the last day of the course, allowing us to compare individual and group scores of pre- and post-course surveys.

Course Design and Implementation

The C.R.E.A.T.E instructional strategy here differed from both the original approach (Hoskins et al. 2011a) designed for upper-level students in which students unpack four papers that follow the same scientific question in their entirety. It also differed from the C.R.E.A.T.E Cornerstone approach for first-years (Gottesman and Hoskins 2013) in which students analyze a pair of popular press articles on the same subject. While we used a set of popular press articles to introduce students to a focal topic, we took a deep and focused dive into just one or two figures from two different primary scientific articles that followed the same scientific question or real-world biological challenge (Table 1). Literature differed across sections as each instructor chose to focus on a scientific question that aligned with their own research interest and expertise. This particular aspect of course design engaged our instructors by giving them some autonomy and allowed us to introduce our first-year students to a diversity of research in biology. Although the different topical focus across the sections of the course varied, all instructors deployed weekly activities associated with the C.R.E.A.T.E pedagogy over the course of the term to reach shared learning goals and outcomes despite the different focal topics across sections (Table 1). To establish evidence-based course structure and maintain consistency across sections of the course we: 1) developed a sandbox site or "shell" on our learning management system that contained all of the shared lesson plans, resources, quizzes, assignments, and activity prompts which we shared with all course instructors for customization prior to the start of the term, and 2) C.R.E.A.T.E'ed a faculty learning community that brought the teaching team together each week for 1 hour to engage in discussions on the course and support one another in the implementation of the pedagogy.

This multi-section course was coordinated by two instructors who planned and facilitated the instructor learning community but had no prior training in C.R.E.A.T.E pedagogy themselves. There were a total of 12 instructors on the teaching team in Term 1 and 14 in Term 2. Each week, the instructor learning community (1) reflected on the previous week together (2) participated in student activities themselves (3) exchanged ideas, resources, and plans for the upcoming week. The instructor

learning community allowed all instructors to implement a highly structured, student-centered approach to teaching each week, share teaching practices, and adapt to curriculum and resources as needed. In general, students across all sections of the course were introduced to content and new concepts outside of class each week. Although early on (typically week 2), some instructors dedicated time to content delivery on their focal topic to help students understand new concepts and the motivation behind the research question, class time was generally structured around the actively engaging C.R.E.A.T.E activities that students completed in (online) breakout rooms with members of their fixed groups of 4-5 students.

C.R.E.A.T.E activities were implemented online using platforms that students could work collaboratively on primarily during class time. The platform Miro (miro.com) allowed students to build concept maps of the introduction section of each paper together while students used the platforms BioRender (biorender.com) and Canva (canva.com) as resources when building cartoons online (Table 1). All instructors in this study were also novices with respect to both the C.R.E.A.T.E pedagogy and online teaching. Our instructors were highly engaged and committed to shared goals and pedagogy but given their different research interests and experiences, selected different focal topics and primary literature for their students.

Survey of Student-Rated Abilities, Attitudes, and Beliefs (SAAB)

To assess student outcomes, we administered the SAAB as described in Hoskins et al (2011). In short, the survey consists of 31 statements across seven categories and two individual questions to which students respond on a five-point Likert-style scale (Table 2). An overall score for each of the seven categories reflect pooled responses to the survey statements. The seven individual categories comprise subsets of statements and address specific aspects of scientific thinking and perceptions of science. Surveys were distributed online using Qualtrics in the first (pre-) and final (post-) class session and took 15-20 minutes to complete based on the survey platform's analytics.

Statistical Analysis

SAAB survey response scores were aggregated into the appropriate topic group (Table 2). The median was used as the average as the response values do not correspond to a continuous scale. A two-way repeated ordinal regression model (or cumulative link mixed model) was used to analyze changes between pre and post course survey results and between instructor groups (R package *ordinal*). Student IDs were coded into random numbers and used as random effects within the ordinal regression model. To identify the best fitting model explaining the observed data, a null model was compared with a model including an interaction term (instructors with pre and post survey, Suppl. Table 1). We used the Laplace approximation, logit distribution and equidistant as threshold and identified group differences using the Tukey's Honest post hoc test comparing the lsmeans (R package *lsmeans* using the sidak approach, Supp Table 2, Suppl. Table 3).

Results

C.R.E.A.T.E. shifts students self-assessed abilities, attitudes, and beliefs about science when implemented online by a diverse team of novice instructors

We used two overarching questions from the C.R.E.A.T.E. survey described in Hoskins (2011) to examine students' self-assessed ability to "*read and analyze scientific journal articles*" and "*understanding of the scientific research process*" across all sections of the first-year laboratory course in the Biology Program in 2020. Overall, we observed significant shifts from students feeling less confident in their abilities and understanding pre-term, left skewed distribution, towards feeling more confident in their abilities post-term, right skewed distribution (Fig. 1A, Table 3). Across all seven question categories of the SAAB survey, we found significant increases in students' confidence in their science skills, abilities, and epistemological beliefs post-term (Table 3).

SAAB outcomes are not instructor dependent

While students of instructors of all ranks shifted significantly with respect to Question 1 (*"confidence to read and analyze journal articles"*) and Question 2 (*"rate your understanding of the scientific process"*) (Fig. 1 A and B), we identified some differences between instructor cohorts for individual SAAB categories. We identified two instructor cohorts that experienced slightly smaller, non-significant shifts in student gains and confidence from pre-term to post-term; students of (1) Associate Professors of Teaching and (2) Assistant Professors of Teaching. However, students of both cohorts reported higher confidence in their ability to *decode primary literature* levels pre-term (Fig. 2A). A total of 40% of students taught by Associate Professors of Teaching and 48% of students taught by Assistant Professors of Teaching, reported confidence levels of 4 (high) and 5 (very high) coming into the course, where as 30% - 38% (median 37%) of students in all other instructor groups reported high (4) to very high (5) levels of confidence (Fig. 2A, Suppl. Table 2).

In addition, cohorts of Assistant Professors of Teaching and Sessional Instructors did not shift to the same degree as students of other instructors in their ability to *actively read* primary literature (Fig. 2C, Suppl. Table 2). Interestingly, when we compared student's pre-term responses to establish a baseline for observed gains across instructors, we found higher confidence in cohorts of Assistant Professor of Teaching and Sessional Instructors compared to the other instructor cohorts (Fig. 2C. Table 4). 58% of the students of Sessional Instructors and 60% of the students taught by the Assistant Professor of Teaching reported high or very high confidence in their ability to *actively read* scientific literature leading to a lower, non-significant gain to the end of the course (Fig. 2C).

While overall, students' epistemological beliefs, or knowledge of the '*scientific publication process and the interpretation of data and forming conclusions*' significantly increased from pre-term to post-term ($p<0.0001$, Table 2, Fig. 3A, B, C), several individual instructor groups were unable to significantly shift their students' epistemological beliefs (Table 4, Suppl. Table 1). Specifically, students of Postdoctoral Research Fellows, Associate Professors of Teaching, Assistant Professors of Teaching, and Research Associate Professors did not significantly improve from pre- to post-term surveys ($p > 0.05$, Table 4, Suppl. Table 2) while students of Research Professors, Lecturers, and Sessional Instructors significantly shifted from reporting "I am not sure" (3) to "I agree" (4) or "I strongly agree" (5) by 7% - 13%. (Fig. 3C. Table 4, Suppl. Table 1). Consistent with pre-term survey response data on skills and abilities, students of the Assistant Professor of Teaching came into the course with relatively sophisticated epistemological beliefs about science (Fig. 3C). Though shifts varied across instructor groups, no significant differences were detected between students taught by instructors of different ranks at the end of term (Table 4).

Discussion

In the present study, we extended the utility of the C.R.E.A.T.E pedagogy to a large, multi-section, team taught first-year undergraduate biology course and showed that it was successfully implemented in the online learning environment. We demonstrated that C.R.E.A.T.E outcomes did not depend on instructor rank, training, and/or teaching experience but rather were achieved through the collaborative work of instructors who met regularly and worked as a learning community. We observed positive shifts in students' confidence in their science skills and abilities across multiple sections taught by different instructors of a single course and showed that instructors using C.R.E.A.T.E online achieved comparable outcomes. Overall, our results expand on the current and growing body of literature demonstrating that the C.R.E.A.T.E pedagogy fosters student efficacy by engaging students in the practices of scientists and extends these outcomes to the virtual classroom.

How our study outcome compares to other C.R.E.A.T.E studies

C.R.E.A.T.E has previously been shown to increase students' self-assessed ability to successfully carry out a range of skills required to comprehend primary scientific literature (Hoskins et al. 2011b; Kenyon et al. 2019b; Pugh-Bernard and Kenyon 2020b). By engaging students in an iterative practice of synthesizing complex information, thinking critically through study design, and interpreting the findings of published science, C.R.E.A.T.E helps students cultivate the skills of scientists (Nordell 2009; Hoskins et al. 2011b; Hartman et al. 2017). Our findings underscore these studies and extend the use of the student-centered activities defining C.R.E.A.T.E pedagogy (i.e. concept mapping, article and figure annotation, and data transformation) to the online teaching and learning environment. Increasing students' confidence in their ability to *do science*, or their science efficacy, is associated with numerous positive outcomes (Graham et al. 2013; Trujillo and Tanner 2014). Self-efficacious students are intrinsically motivated, more likely to challenge themselves, able to recover from failure and setbacks, and more likely to achieve their goals. Increases in student efficacy have even been shown to close gaps and improve academic performance of students historically underserved in science (Ballen et al. 2017).

We show that instructors of various ranks and levels of teaching experience can achieve similar student outcomes in the affective domain when implementing the evidence-based teaching practice C.R.E.A.T.E. with no formal training in this pedagogy. We observed no differences in student outcomes between tenured and untenured instructors. Kenyon et al (2019) hypothesized that professional status may influence student outcomes as tenured faculty may have "more flexibility in course selection or design" than untenured faculty. While this may be true if individual instructors were constrained by different parameters, our data indicate that the pedagogy is versatile when implemented by instructors of various ranks and when working with a comparable degree of flexibility. Although individual categories of questions in this study revealed differences between instructors, such differences can be explained by pre-term survey results which show differences across sections in students coming into the course. For example, we found significant differences between instructors in the question categories '*F1: Decoding Primary Literature*' and '*F3: Active Reading,*' however, these were due to differences in student's self-assessed abilities prior to the start of the course and those differences did not translate to the end of the course resulting in comparable confidence levels. These findings clearly demonstrate that the C.R.E.A.T.E approach is capable of shifting students' self-assessed beliefs in their ability to think and do science. These results argue professional status alone

does not affect student outcomes but do not pinpoint exactly how instructors achieved comparable outcomes together. Previous research has elucidated the value of alignment between instructor intentions, defined as "instructors' goals for carrying out a specific task with students" and instructor support, defined as "what instructors say to students during interactions" (Cooper et al. 2022). In the present study, the teaching team explicitly discussed their shared intentions each week but individual instructor support likely varied across sections given the range of teaching and research experiences that different instructors brought to the course. In future work we hope to characterize instruction in the different learning environments using instruments like the Classroom Discourse Observation Protocol (Kranzfelder et al. 2019) and explore how instructor talk influences student outcomes across instructor groups (Seidel et al. 2015). This work will contribute to our understanding of how a diverse group of instructors can achieve shared goals using curriculum they themselves did not design.

Unlike previous studies in which newly trained faculty achieved positive student gains and outcomes after attending a C.R.E.A.T.E workshop facilitated by experts, none of the instructors in this study received formal training prior to the start of their C.R.E.A.T.E course (Stevens and Hoskins 2014; Kenyon et al. 2016, 2019a). Due to the immediate shift to remote teaching and learning during the COVID-19 pandemic, this course was quickly redesigned for remote teaching and learning. Instructors did not have the opportunity to receive formal training in new pedagogy or online tools. However, we show that faculty new to teaching C.R.E.A.T.E and who are also new to online teaching and learning can successfully increase students' efficacy and epistemological beliefs about science.

An instructor learning community supports the adoption of evidence-based practice

We attribute the successful implementation of C.R.E.A.T.E here to our instructors' commitment to a learning community. We define an instructor learning community as a cross-disciplinary group of various instructor types which collaborates as an instructional team throughout the term but differentiate between our *instructor* learning community and more commonly referenced *faculty* learning community as not all participants were faculty members (Cox 2001). Instructors actively participated in C.R.E.A.T.E learning activities during our weekly community meetings. The meetings provided a space for instructors to discuss challenges, highlight successes, and build confidence before taking the risks involved in the implementation of new pedagogy. Previous studies have found that different instructors make different decisions on their instructional strategies based on their personal attitudes rather than pedagogical evidence (Andrews and Lemons 2015; Turpen et al. 2016). In the present study, the instructor learning community was facilitated by a faculty member that centered discussions on pedagogical evidence and shared goals but also created space for individuals to reflect on and share their personal attitudes and beliefs about teaching and learning. Facilitation was guided by the principles of self-determination theory in which instructors cultivated *competence* by piloting C.R.E.A.T.E. activities themselves, *relatedness* by connecting over shared goals and challenges, and *autonomy* by bringing themselves and their own choices into weekly meetings (Niemiec and Ryan 2009). Our results indicate that instructor learning communities may attenuate barriers to pedagogical change within departments by providing inclusive opportunities to engage instructors of various ranks in shared goals and discussion on teaching and learning. Unlike many professional development opportunities that facilitate the renewal of teaching practices such as workshops and seminars which require voluntary and additional time commitments that impede the introduction of new pedagogy, our instructor learning community was an integral part of the course.

The affective domain of learning as a course design feature for high impact teaching

This study analyzed self-assessment data from students to explore the affective domain of learning, specifically the construct of students' science efficacy, in the online environment during the COVID19 pandemic. The affective domain of learning is concerned with the feelings that arise throughout the learning process which influence learning outcomes. It is distinguished from the cognitive domain of learning in that it is defined by feelings and attitudes as opposed to knowledge and intellectual skills (Krathwohl et al. 1964). The affective domain of learning became especially important for educators when the COVID19 pandemic brought unprecedented challenges to students around the world. In the absence of the campus community that often accompanies the university student experience, undergraduates felt disconnected from important resources (Camfield et al. 2021; Gin et al. 2021; Mohammed et al. 2022). This led to a loss of resilience, engagement, and sense of belonging (Camfield et al. 2021). First-year students in particular were especially vulnerable given the role that instructors and access to peer community plays in fostering or "mediating" efficacy and empowering learners as they transition to a more independent learning environment (Hammond 2015; Camfield 2016). Now, as we move beyond many of the challenges that the COVID19 pandemic initially posed to post-secondary education and settle into a new normal, we carry with us valuable lessons learned about the noncognitive factors that contribute to student success and hopefully a heightened sense of empathy for our students. This is particularly important in the STEM fields where the affective domain of learning has traditionally garnered less attention than the cognitive domain yet, when given sufficient attention, has been shown to help all STEM students thrive, especially those with visible or invisible disabilities and those from historically underrepresented backgrounds that may be hesitant about their social belonging (Cohen et al. 2006; Walton and Cohen 2011; Bauer et al. 2020; Camfield et al. 2021; Mohammed et al. 2022).

Increases in efficacy have previously been linked to classroom activities that engage students in reading and evaluating scientific literature. Furthermore, high impact teaching activities that actively engage students, promote collaboration, and cultivate community have been shown to foster science identity which in turn promotes short and long term outcomes such as increased efficacy and persistence in STEM (Graham et al. 2013; Corwin et al. 2015; Bauer et al. 2020). Students in this study worked in fixed small groups on C.R.E.A.T.E activities throughout the term and informal feedback from students corroborates the idea that collaboration in the form of group work was an integral part of the course that likely contributed to a strong sense of belonging and may have even enhanced students' science identity. Given that high impact, evidence-based practices that address both the cognitive and affective domains of learning were course design features, future work is needed to further elucidate the exact mechanism by which students developed efficacy.

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Figure 1. Pre- and post-term SAAB survey results of two summary questions A) "*On a scale of 1 to 5, rate your confidence in your ability to read and analyze science journal articles.*", B) "*On a scale of 1 to 5, rate your understanding of the way scientific research is done of the scientific research process.*"

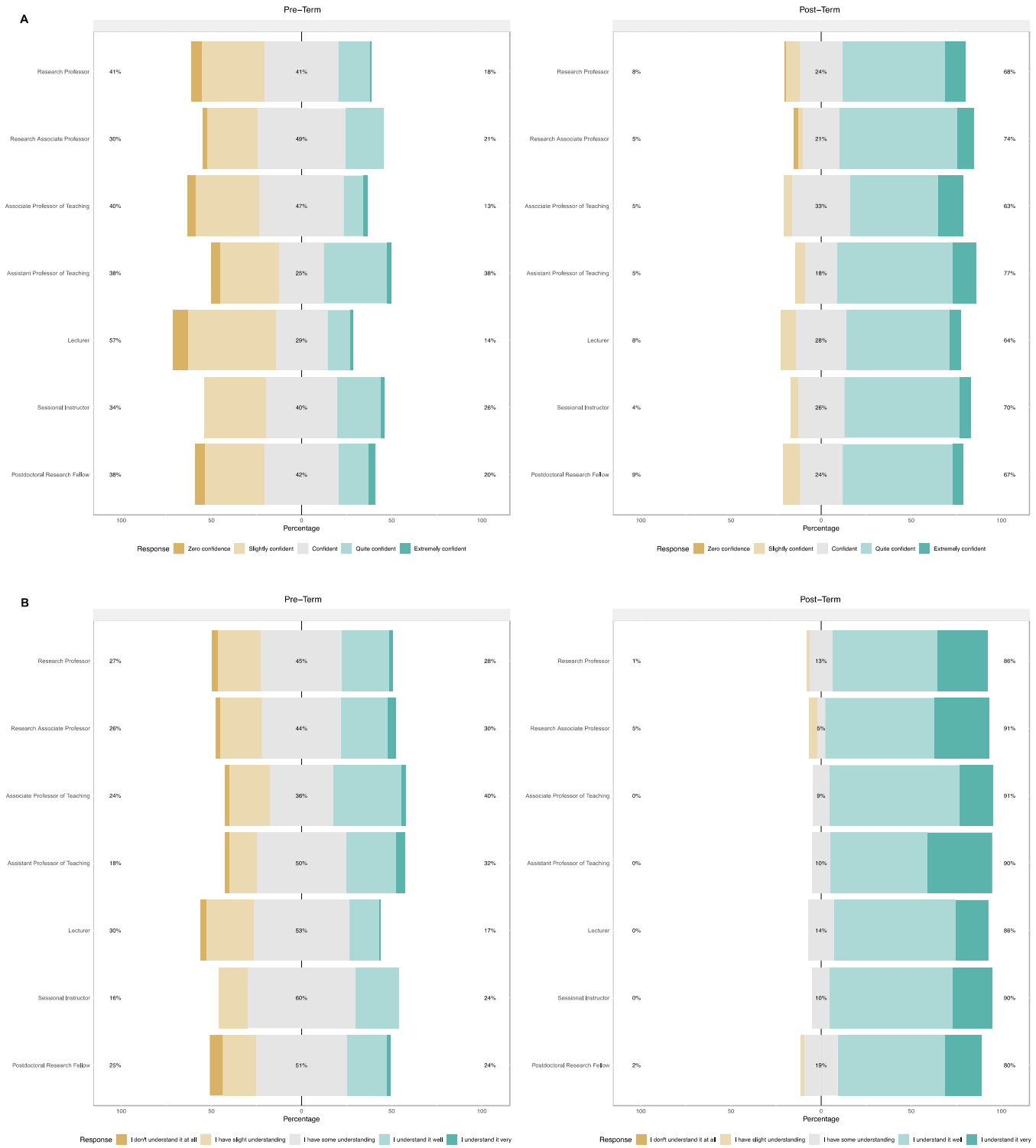

Figure 2. Pre- and post-term SAAB survey results of A) F1: *Decoding Primary Literature*, B) F2: *Interpreting Data*, C) F3: *Active Reading*, D) F4: *Visualization*

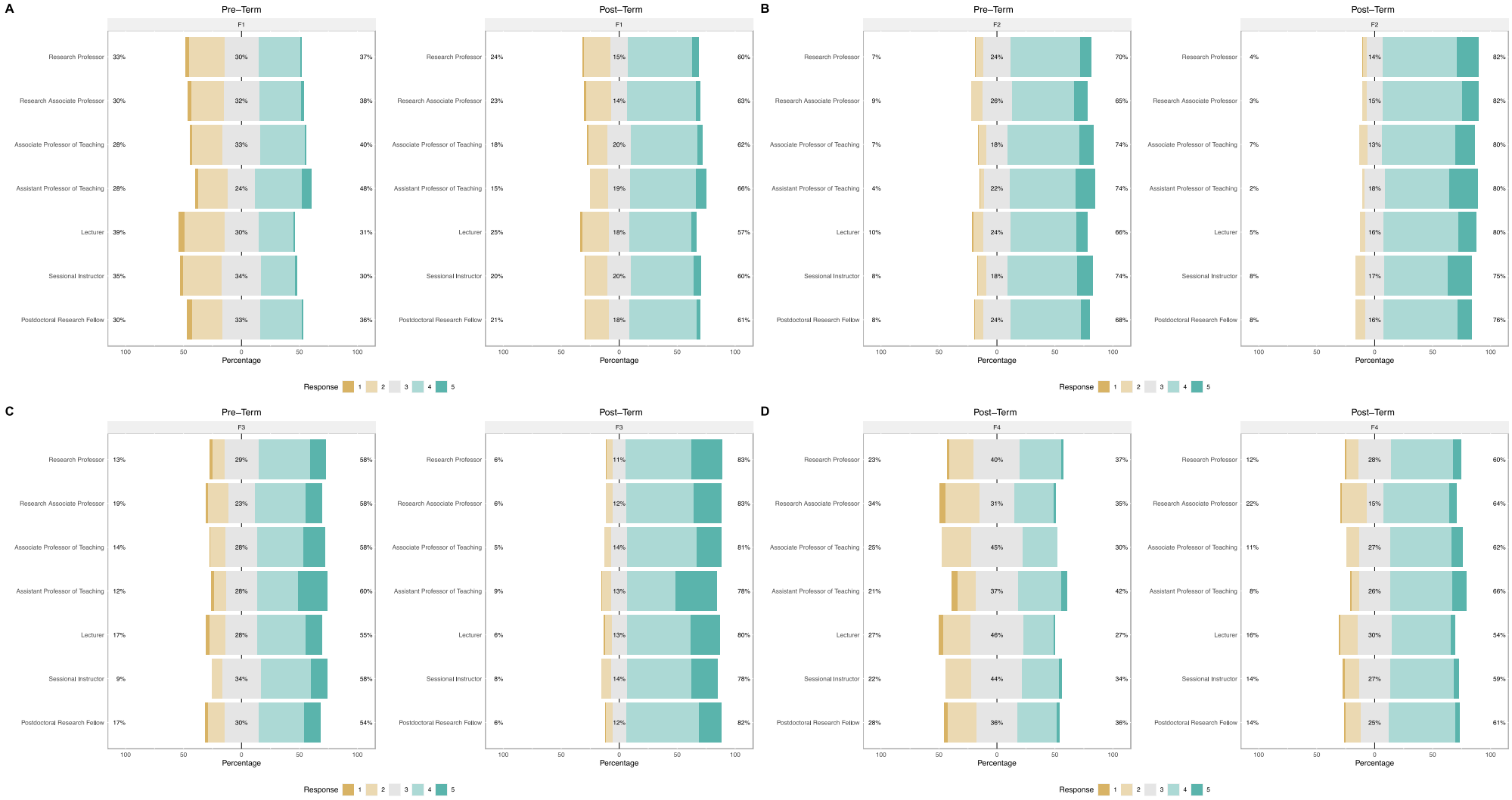

Figure 3. Pre- and post-term surveys SAAB result of A) F5: *Thinking Like A Scientist*, B) F6: *Research in Context*, C) F7: *Knowledge is Certain*

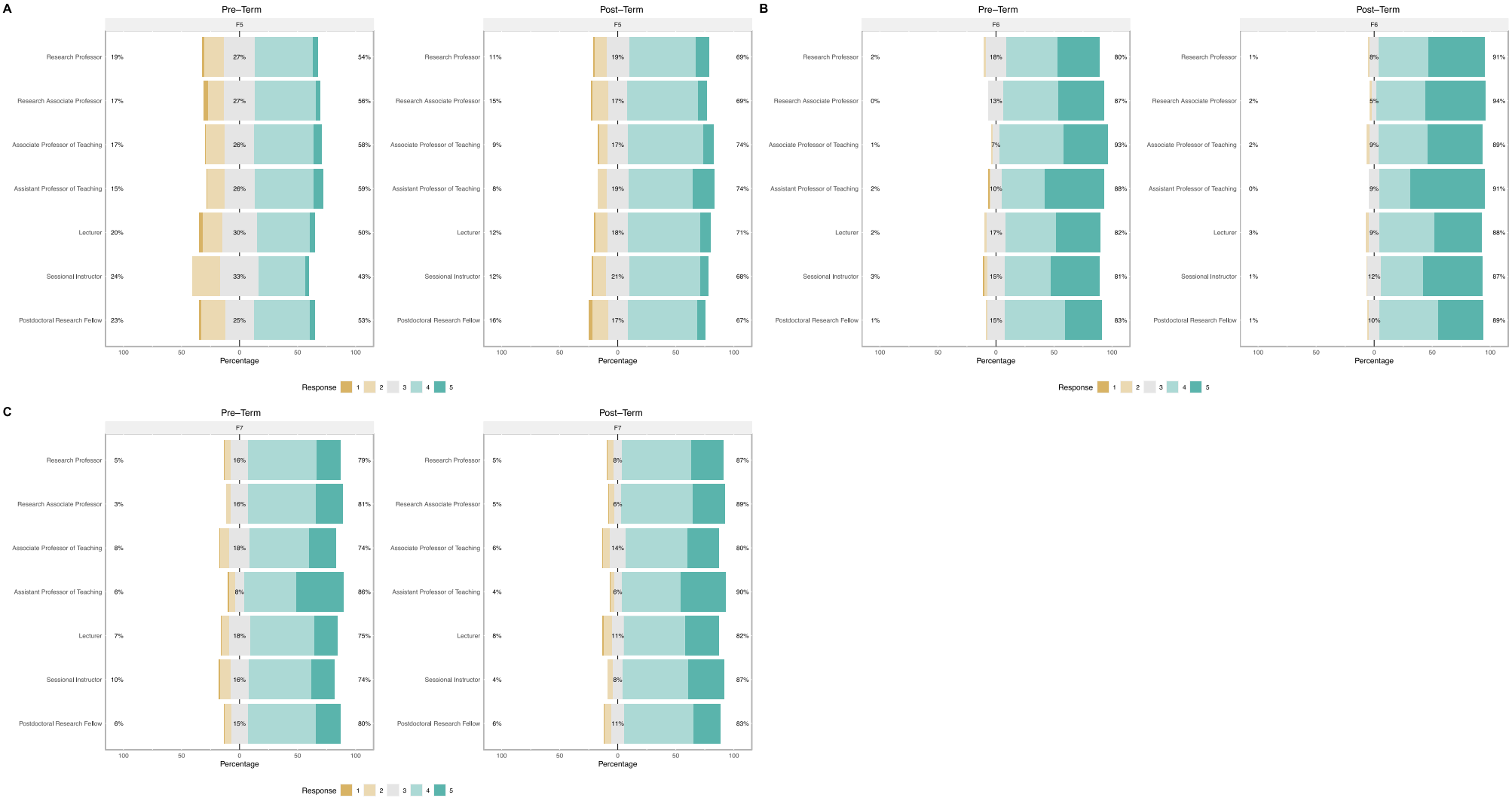

Table 1. Course schedule of general topics, learning objectives and learning activities

Week	Topic	Learning Objectives	Key learning activity
1	Class Introductions and Community Building		
2	Popular Press	Outline the process of science presented in the article Summarize a current idea or challenge in biology Relate science to society	Map the process of science from a popular press piece (https://undsci.berkeley.edu/interactive/#/main)
3	The Process of Science	Distinguish between hypotheses and predictions Differentiate between exploratory and explanatory research Apply your understanding of the process of science to a current scientific study	
4	Scientific Paper #1: Introduction Section (**C**onsider and **R**ead)	Use information in the introduction section of a paper or article to build a concept map Define relationships between key terms and concepts Describe the structure of a scientific paper	Concept mapping
5	Scientific Paper #1: Figure analysis (**E**lucidate a hypothesis and **A**nalyze and interpret data)	Unpack a figure Analyze and interpret data Identify a study limitation Cartoon a figure	Cartoon a figure
6	Scientific Paper #1: Design the next experiment (**T**hink of the next **E**xperiment)	Question claims or conclusions Evaluate sampling protocols Distinguish between correlation and causation Creatively design a follow up experiment and plan for analyzing data	Pitch a follow up experiment
7	Midterm		
8	Scientific Paper #2: Introduction Section (**C**onsider and **R**ead)	Use information in the introduction section of a paper or article to build a concept map Define relationships between key terms and concepts Describe the structure of a scientific paper	Concept mapping
9	Scientific Paper #2: Figure analysis	Unpack a figure	Cartoon a figure

	(**E**lucidate a hypothesis and **A**nalyze and interpret data)	Analyze and interpret data Identify a study limitation Cartoon a figure	
10	Scientific Paper #2: (**T**hink of the next **E**xperiment)	Question claims or conclusions Evaluate sampling protocols Distinguish between correlation and causation Creatively design a follow up experiment and plan for analyzing data	Pitch a follow up experiment
11-12	Final projects		Final project symposium

Table 2. Survey of Student-Rated Abilities, Attitudes, and Beliefs (SAAB). Each question had the same response values available to students: "I strongly disagree" (1), "I disagree" (2), "I am not sure" (3), "I agree" (4), and "I strongly agree" (5), though for the purposes of scoring a number of statements are reverse-coded (i.e., "I strongly agree" would be scored as 1 while "I strongly disagree" would be scored as 5 in such cases). We have indicated reverse-coded statements with an asterisk in this table.

Question Group	Question	Student Answers (Code Value)
F1 Decoding Primary Literature	The scientific literature is difficult to understand.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	When I see scientific journal articles, it looks like a foreign language to me.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	I am not intimidated by the scientific language in journal articles.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	I am confident in my ability to critically review scientific literature.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	I am comfortable defending my ideas about experiments.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
F2 Interpretin g Data	It is easy for me to transform data, like converting numbers from a table to percentages.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	If I see data in a table, it is easy for me to understand what it means.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	If I am shown data (graphs, tables, charts), I am confident that I can figure out what it means.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)

	It is easy for me to relate the results of a single experiment to the big picture.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
F3 Active Reading	I could make a simple diagram that provides an overview of an entire experiment.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	If I am assigned to read a scientific paper, I typically look at the methods section to understand how the data were collected.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	I do not know how to design a good experiment	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	The way that you display your data can affect whether or not people believe it.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
F4 Visualizatio n	When I read scientific material it is easy for me to visualize the experiments that were done.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	If I look at data presented in a paper, I can visualize the method that produced the data.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	When I read a paper, I have a clear sense of what physically went on in a lab/field to produce the results and information I am reading.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
F5 Thinking Like A Scientist	After I read a scientific paper, I don't think I could explain it to somebody else	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	I am confident I could read a scientific paper and explain it to another person.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	I enjoy thinking of additional experiments when I read scientific papers.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)

	I accept the information about science presented in newspaper articles without challenging it.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
F6 Research in Context	Experiments in “model organisms” like the fruit fly have led to important advances in understanding human biology.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	Progress in curing diseases has been made as a result of experiments on lower organisms like worms and flies.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	I understand why experiments have controls.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
F7 Knowledge is Certain	If two different groups of scientists study the same question, they will come to similar conclusions.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	The data from a scientific experiment can only be interpreted in one way.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	Because scientific papers have been critically reviewed before being published, it is unlikely that there will be flaws in scientific papers.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	Because all scientific papers are reviewed by other scientists before they are published, the information in the papers must be true.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)
	Sometimes published papers must be reinterpreted when new data emerge years later.	I strongly disagree (1), I disagree (2), I am not sure (3), I agree (4), I strongly agree (5)
	Results that do not fit into the established theory are probably wrong.	I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5)

Table 3. Descriptive analysis of survey results

	Instructor	Pre-Term Survey			Post-Term Survey		
		n	Median	SE	n	Median	SE
QU1: "On a scale of 1–5, rate your confidence in your ability to read and analyze science journal articles."	Research Professor	219	3	0.056	216	4	0.054
	Postdoctoral Research Fellow	55	3	0.123	54	4	0.099
	Lecturer	132	3	0.076	132	4	0.063
	Associate Professor of Teaching	45	3	0.121	43	4	0.117
	Assistant Professor of Teaching	40	3	0.158	39	4	0.114
	Sessional Instructor	50	3	0.115	50	4	0.091
	Research Associate Professor	43	3	0.116	43	4	0.114

QU2: “On a scale of 1–5, rate your understanding of “the way scientific research is done” or “the scientific research process.”	Research Professor	219	3	0.057	216	4	0.046
	Postdoctoral Research Fellow	55	3	0.118	54	4	0.093
	Lecturer	132	3	0.066	132	4	0.049
	Associate Professor of Teaching	45	3	0.131	43	4	0.080
	Assistant Professor of Teaching	40	3	0.133	39	4	0.102
	Sessional Instructor	50	3	0.089	50	4	0.079
	Research Associate Professor	43	3	0.134	43	4	0.110

F1	Research Professor	1095	3	0.028	1080	4	0.031
	Postdoctoral Research Fellow	275	2	0.050	270	2	0.056
	Lecturer	660	3	0.035	660	4	0.039
	Associate Professor of Teaching	225	2	0.052	215	3	0.062
	Assistant Professor of Teaching	200	4	0.074	195	4	0.059
	Sessional Instructor	250	3	0.055	250	4	0.056
	Research Associate Professor	215	3	0.062	215	3	0.074
F2	Research Professor	876	4	0.025	863	4	0.024
	Postdoctoral Research Fellow	220	4	0.049	216	4	0.051
	Lecturer	528	4	0.035	528	4	0.030
	Associate	180	4	0.057	172	4	0.057

	Professor of Teaching						
	Assistant Professor of Teaching	160	4	0.059	156	4	0.057
	Sessional Instructor	200	4	0.055	199	4	0.058
	Research Associate Professor	172	4	0.061	172	4	0.049
F3	Research Professor	876	3	0.036	864	4	0.040
	Postdoctoral Research Fellow	220	3	0.073	216	4	0.081
	Lecturer	528	3	0.049	528	4	0.052
	Associate Professor of Teaching	180	3	0.085	172	4	0.090
	Assistant Professor of Teaching	160	3	0.094	156	4	0.097
	Sessional Instructor	200	4	0.059	200	4	0.059

	Research Associate Professor	172	3	0.085	172	4	0.093
F4	Research Professor	657	3	0.032	648	4	0.032
	Postdoctoral Research Fellow	165	3	0.069	162	4	0.064
	Lecturer	396	3	0.042	396	4	0.041
	Associate Professor of Teaching	135	3	0.064	129	4	0.071
	Assistant Professor of Teaching	120	3	0.086	117	4	0.074
	Sessional Instructor	150	3	0.063	150	4	0.67
	Research Associate Professor	129	3	0.083	129	4	0.081
F5	Research Professor	876	4	0.030	864	4	0.029

	Postdoctoral Research Fellow	216	4	0.62	216	4	0.063
	Lecturer	528	4	0.039	528	4	0.036
	Associate Professor of Teaching	180	4	0.064	172	4	0.059
	Assistant Professor of Teaching	160	4	0.068	156	4	0.065
	Sessional Instructor	200	3	0.059	200	4	0.057
	Research Associate Professor	172	4	0.068	172	4	0.065
F6	Research Professor	657	4	0.030	648	4	0.027
	Postdoctoral Research Fellow	162	4	0.056	162	4	0.054
	Lecturer	396	4	0.038	396	4	0.037
	Associate Professor of Teaching	135	4	0.054	129	4	0.065

	Assistant Professor of Teaching	120	5	0.070	117	5	0.061
	Sessional Instructor	150	4	0.069	150	5	0.059
	Research Associate Professor	129	4	0.060	129	5	0.058
F7	Research Professor	1314	4	0.021	1296	4	0.021
	Postdoctoral Research Fellow	324	4	0.043	324	4	0.043
	Lecturer	792	4	0.029	792	4	0.031
	Associate Professor of Teaching	270	4	0.052	258	4	0.051
	Assistant Professor of Teaching	240	4	0.055	234	4	0.049
	Sessional Instructor	300	4	0.051	300	4	0.043
	Research Associate	258	4	0.045	258	4	0.046

	Professor						

Table 4. Ordinal logistic regression model results of survey using an analysis of variance (ANOVA). Asterix identifies significance levels with *** = p<0.001, ** = <0.01, * = <0.05.

	Coefficients	LR Chi square	Df	Pr (> Chisq)
QU1	Pre-Post term	463.74	1	<0.001***
	Instructor	14.06	6	0.029*
	Pre-Postterm X Instructor	9.19	6	0.163
QU2	Pre.Post	552.85	1	<0.001***
	Instructor	11.52	6	0.07
	Pre-Postterm x Instructor	3.22	6	0.78
F1	Pre.Post	139.38	1	<0.001***
	Instructor	46.36	6	<0.001***
	Pre-Postterm x Instructor	17.29	6	0.008**
F2	Pre.Post	137.39	1	<0.001***
	Instructor	5.59	6	0.47
	Pre-Postterm x Instructor	14.10	6	0.03*
F3	Pre.Post	245.88	1	<0.001***
	Instructor	102.39	6	<0.001***
	Pre-Postterm x Instructor	3.80	6	0.703
F4	Pre.Post	369.01	1	<0.001***
	Instructor	11.73	6	0.07
	Pre-Postterm x	3.94	6	0.05

	Instructor			
F5	Pre.Post	211.69	1	<0.001***
	Instructor	10.42	6	0.11
	Pre-Postterm x Instructor	5.61	6	0.47
F6	Pre.Post	50.59	1	<0.001***
	Instructor	21.09	6	0.002**
	Pre-Post x Instructor	8.26	6	0.22
F7	Pre.Post	78.85	1	<0.001***
	Instructor	15.57	6	0.016*
	Pre-Post x Instructor	12.18	6	0.04*

Appendix:

Supplementary Table 1. Model comparison using the likelihood ratio test of cumulative link models. Link = threshold; logit distribution = equidistant. Asterix identifies significance levels with *** = p<0.001, ** = <0.01, * = <0.05.

QU1	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
	No. par	AIC	logLik	LR.stat	df	Pr(>Chisp)
model.fixed	15	2792.7	-1381.4			
model	16	27.13.5	-1340.7	81.25	1	<0.001***
QU2	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
	No. par	AIC	logLik	LR.stat	df	Pr(>Chisp)
model.fixed	15	2552.9	-1261.5			
model	16	2525.1	-1246.6	29.78	1	<0.001***
F1	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
model.fixed	15	7743.2	-3856.6			
model	16	7381.9	-3675.0	363.32	1	<0.001***
F2	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
model.fixed	15	12857	-6413.4			
model	16	12132	-6.049.8	727.37	1	<0.001***
F3	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
model.fixed	15	17480	-8724.8			
model	16	17461	-8714.7	20.39	1	<0.001***

F4	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
model.fixed	15	10924	-5447.1			
model	16	10145	-5056.5	781.22	1	<0.001***
F5	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
model.fixed	15	14682	-7325.8			
model	16	14232	-7099.8	451.98	1	<0.001***
F6	model.fixed : Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor Model: Likert score ~ Pre.Post + Instructor + Pre.Post:Instructor + (1|Student.Code)					
model.fixed	15	9189.6	-4579.8			
model	16	8901.7	-44.34.8	289.94	1	<0.001***
F7						
model.fixed	15	20081	-10025.7			
model	16	19348	-9658.2	735.06	1	<0.001*

Supplementary Table 2. Post Hoc test results using sidak comparison, confidence level = 0.95, significance level used: alpha = 0.05. Letters indicate grouping

Question	Coefficient	Term survey	lsmeans	SE	df	Asymp. LCL	Asymp, UCL	.group
QU1	Assistant Professor of Teaching	Post	-2.61	0.41	Inf	-3.81	-1.41	a
	Research Associate Professor	Post	-2.49	0.39	Inf	-3.64	-1.34	a
	Sessional Instructor	Post	-2.30	0.36	Inf	-3.35	-1.25	a
	Research Professor	Post	-2.26	0.19	Inf	-2.83	-1.70	a
	Associate Professor of Teaching	Post	-2.25	0.39	Inf	-3.39	-1.11	a
	Lecturer	Post	-1.97	0.23	Inf	-2.64	-1.30	a
	Postdoctoral Research Fellow	Post	-1.97	0.34	Inf	-2.97	-0.97	a
	Assistant Professor of Teaching	Pre	-0.8	0.41	Inf	-1.27	1.12	b
	Sessional Instructor	Pre	0.23	0.35	Inf	-0.81	1.27	bc
	Research Associat	Pre	0.37	0.38	Inf	-0.75	1.48	bc

	e Professor							
	Postdoctoral Research Fellow	Pre	0.64	0.34	Inf	-0.35	1.63	bc
	Research Professor	Pre	0.87	0.17	Inf	0.37	1.38	bc
	Associate Professor of Teaching	Pre	0.95	0.37	Inf	-0.14	2.04	bc
	Lecturer	Pre	1.61	0.22	Inf	0.94	2.27	c
QU2	Assistant Prof of Teaching	Post	-3.88	0.39	Inf	-5.03	-2.73	a
	Research Associate Professor	Post	-3.65	0.37	Inf	-4.75	-2.56	a
	Research Professor	Post	-3.46	0.21	Inf	-4.07	-2.86	a
	Sessional Instructor	Post	-3.42	0.34	Inf	-4.42	-2.43	a
	Associate Professor of Teaching	Post	-3.36	0.36	Inf	-4.41	-2.30	a
	Lecturer	Post	-3.15	0.23	Inf	-3.82	-2.48	a
	Postdoctoral Research	Post	-2.99	0.33	Inf	-3.94	-2.04	a

	Fellow							
	Assistant Professor of Teaching	Pre	-0.58	0.34	Inf	-1.64	0.48	b
	Associate Professor of Teaching	Pre	-0.54	0.34	Inf	-1.54	0.46	b
	Sessional Instructor	Pre	-0.24	0.31	Inf	-1.15	0.66	b
	Research Associate Professor	Pre	-0.18	0.35	Inf	-1.20	0.85	b
	Presearch Professor	Pre	0.002	0.15	Inf	-0.45	0.45	b
	Postdoctoral Research Fellow	Pre	0.17	0.31	Inf	-0.73	1.06	b
	Lecturer	Pre	0.41	0.19	Inf	-0.15	0.98	b
F1	Lecturer	Pre	-0.23	0.09	Inf	-0.47	0.02	a
	Sessional Instructor	Pre	-0.12	0.14	Inf	-0.53	0.29	ab
	Postdoctoral Research Fellow	Pre	-0.05	0.11	Inf	-0.37	0.27	ab
	Associate Professo	Pre	0.11	0.08	Inf	-0.13	0.35	ab

	r of Teaching							
	Research Professor	Pre	0.11	0.06	Inf	-0.06	0.28	ab
	Research Associate Professor	Pre	0.18	0.15	Inf	-0.24	0.60	abc
	Assistant Professor of Teaching	Pre	0.47	0.14	Inf	0.05	0.89	bcd
	Postdoctoral Research Fellow	Post	0.63	0.12	Inf	0.28	0.98	cde
	Lecturer	Post	0.66	0.09	Inf	0.40	0.91	cde
	Associate Professor of Teaching	Post	0.68	0.15	Inf	0.26	1.11	cde
	Research Professor	Post	0.78	0.07	Inf	0.59	0.97	de
	Research Associate Professor	Post	0.81	0.14	Inf	0.39	1.22	de
	Sessional Instructor	Post	1.02	0.14	Inf	0.61	1.44	de
	Assistant Professor of Teaching	Post	1.09	0.15	Inf	0.64	1.54	e

F2	Lecturer	Pre	-0.23	0.09	Inf	-0.48	0.02	a
	Sessional Instructor	Pre	-0.12	0.14	Inf	-0.53	0.29	ab
	Postdoctoral Research Fellow	Pre	-0.05	0.11	Inf	-0.37	0.27	ab
	Associate Professor of Teaching	Pre	0.11	0.08	Inf	-0.13	0.35	ab
	Research Professor	Pre	0.11	0.06	Inf	-0.06	0.28	ab
	Research Associate Professor	Pre	0.18	0.15	Inf	-0.24	0.60	abc
	Assistant Professor of Teaching	Pre	0.47	0.14	Inf	0.05	0.89	bcd
	Postdoctoral Research Fellow	Post	0.63	0.12	Inf	0.28	0.98	cde
	Lecturer	Post	0.66	0.09	Inf	0.40	0.91	cde
	Associate Professor of Teaching	Post	0.68	0.15	Inf	0.26	1.11	cde
	Research Professor	Post	0.78	0.07	Inf	0.59	0.97	de
	Research Associate	Post	0.81	0.14	Inf	0.39	1.21	de

	Professor							
	Sessional Instructor	Post	1.02	0.14	Inf	0.61	1.44	de
	Assistant Professor of Teaching	Post	1.09	0.15	Inf	0.64	1.54	e
F3	Postdoctoral Research Fellow	Pre	-0.24	0.10	Inf	-0.54	0.06	a
	Associate Professor of Teaching	Pre	-0.17	0.08	Inf	-0.39	0.06	a
	Research Associate Professor	Pre	-0.10	0.14	Inf	-0.50	0.30	ab
	Lecturer	Pre	0.07	0.08	Inf	-0.16	0.31	abc
	Research Professor	Pre	0.13	0.06	Inf	-0.03	0.29	abc
	Postdoctoral Research Fellow	Post	0.50	0.12	Inf	0.16	0.84	bcd
	Assistant Professor of Teaching	Pre	0.52	0.14	Inf	0.12	0.92	bcde
	Associate Professor of Teaching	Post	0.58	0.14	Inf	0.16	1.00	cdef

	Research Associate Professor	Post	0.63	0.14	Inf	0.23	1.02	def
	Lecturer	Post	0.88	0.08	Inf	0.64	1.12	def
	Sessional Instructor	Pre	0.96	0.13	Inf	0.59	1.34	defg
	Research Professor	Post	0.99	0.06	Inf	0.80	1.18	ef
	Assistant Professor of Teaching	Post	1.21	0.15	Inf	0.76	1.65	fg
	Sessional Instructor	Post	1.49	0.13	Inf	1.10	1.87	g
F4	Research Associate Professor	Pre	-0.04	0.27	Inf	-0.82	0.73	a
	Lecturer	Pre	-0.03	0.15	Inf	-0.48	0.42	a
	Postdoctoral Research Fellow	Pre	0.14	0.19	Inf	-0.44	0.71	a
	Associate Professor of Teaching	Pre	0.36	0.15	Inf	-0.08	0.79	a
	Research Professor	Pre	0.37	0.11	Inf	0.06	0.69	a
	Sessiona	Pre	0.39	0.26	Inf	-0.37	1.17	ab

	l Instructor							
	Assistant Professor of Teaching	Pre	0.77	0.26	Inf	0.01	1.54	abc
	Lecturer	Post	1.29	0.16	Inf	0.83	1.74	bcd
	Postdoctoral Research Fellow	Post	1.38	0.21	Inf	0.77	1.99	bcd
	Research Associate Professor	Post	1.39	0.26	Inf	0.65	2.14	bcd
	Sessional Instructor	Post	1.49	0.27	Inf	0.71	2.26	cd
	Research Professor	Post	1.55	0.13	Inf	1.21	1.89	cd
	Associate Professor of Teaching	Post	1.94	0.24	Inf	1.24	2.64	cd
	Assistant Professor of Teaching	Post	2.09	0.28	Inf	1.27	2.90	d
F5	Sessional Instructor	Pre	0.58	0.19	Inf	0.02	1.13	a
	Postdoctoral Research Fellow	Pre	0.89	0.14	Inf	0.46	1.32	ab

	Lecturer	Pre	0.96	0.11	Inf	0.63	1.29	abc
	Research Professor	Pre	1.02	0.08	Inf	0.79	1.26	abc
	Research Associate Professor	Pre	1.12	0.19	Inf	0.55	1.68	abcd
	Associate Professor of Teaching	Pre	1.13	0.11	Inf	0.81	1.45	abc
	Assistant Professor of Teaching	Pre	1.36	0.19	Inf	0.77	1.88	abcde
	Postdoctoral Researcher	Post	1.51	0.16	Inf	1.05	1.96	cdef
	Research Associate Professor	Post	1.62	0.19	Inf	1.07	2.17	bcdef
	Sessional Instructor	Post	1.64	0.19	Inf	1.08	2.20	bcdef
	Lecturer	Post	1.78	0.12	Inf	1.45	2.12	def
	Research Professor	Post	1.85	0.09	Inf	1.59	2.11	ef
	Associate Professor of Teaching	Post	1.85	0.18	Inf	1.32	2.39	def
	Assistant Professo	Post	2.11	0.21	Inf	1.51	2.70	f

	r of Teaching							
F6	Postdoctoral Research Fellow	Pre	2.99	0.17	Inf	2.49	3.49	a
	Research Professor	Pre	3.12	0.11	Inf	2.81	3.43	a
	Lecturer	Pre	3.14	0.14	Inf	2.73	3.55	a
	Postdoctoral Research Fellow	Post	3.20	0.19	Inf	2.66	3.74	ab
	Research Associate	Pre	3.25	0.23	Inf	2.59	3.90	abc
	Sessional Instructor	Pre	3.25	0.23	Inf	2.59	3.91	abc
	Associate Professor of Teaching	Pre	3.30	0.14	Inf	2.90	3.70	ab
	Lecturer	Post	3.39	0.14	Inf	2.98	3.81	ab
	Associate Professor of Teaching	Post	3.62	0.23	Inf	2.97	4.28	abc
	Research Associate Professor	Post	3.75	0.23	Inf	3.09	4.42	abc
	Sessional Instructo	Post	3.76	0.23	Inf	3.08	4.43	abc

	r							
	Research Professor	Post	3.79	0.12	Inf	3.44	4.14	bc
	Assistant Professor of Teaching	Pre	3.88	0.24	Inf	3.20	4.57	abc
	Assistant Professor of Teaching	Post	4.36	0.26	Inf	3.60	5.12	c
F7	Sessional Instructor	Pre	2.30	0.18	Inf	1.78	2.81	Abc
	Postdoctoral Research Fellow	Pre	2.37	0.13	Inf	1.99	2.75	Ab d
	Lecturer	Pre	2.40	0.11	Inf	2.09	2.70	a
	Associate Professor of Teaching	Pre	2.40	0.10	Inf	2.10	2.70	ab
	Research Professor	Pre	2.43	0.08	Inf	2.20	2.65	ab
	Postdoctoral Research Fellow	Post	2.54	0.14	Inf	2.13	2.95	abcde
	Research Associate Professor	Pre	2.55	0.17	Inf	2.05	3.06	abcde
	Associate	Post	2.68	0.16	Inf	2.20	3.16	abcde

	Professor of Teaching							
	Research Associate Professor	Post	2.79	0.17	Inf	2.29	3.29	abcde
	Lecturer	Post	2.81	0.11	Inf	2.50	3.13	bcde
	Research Professor	Post	2.89	0.08	Inf	2.65	3.14	c e
	Sessional Instructor	Post	3.08	0.18	Inf	2.56	3.59	de
	Assistant Professor of Teaching	Pre	3.11	0.18	Inf	2.59	3.63	c e
	Assistant Professor of Teaching	Post	3.25	0.19	Inf	2.70	3.80	e

Table 3. Tukey Post Hoc Test of only pre-term and post-term comparison. Bold values represent significant differences (p = 0.05).

Pre-Post	Q1	Q2	F1	F2	F3	F4	F5	F6	F7
Research Professor	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**
Associate Professor of Teaching	**<.0001**	0.9914	**0.0150**	0.3147	**0.0003**	**<.0001**	**<.0001**	0.9732	0.9004
Lecturer	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	0.8627	**0.0013**
Postdoctoral Research Fellow	**<.0001**	**<.0001**	**0.0002**	0.9826	**0.0001**	**<.0001**	**0.0221**	0.9985	0.9956
Research Associate Professor	**<.0001**	**<.0001**	**0.0167**	**0.0215**	**0.0058**	**<.0001**	0.3965	0.6989	0.9718
Assistant Professor of Teaching	**<.0001**	**<.0001**	**0.0353**	0.5276	**0.0328**	**<.0001**	**0.0136**	0.9028	1.0000
Sessional Instructor	**<.0001**	**<.0001**	**<.0001**	0.9785	0.1201	**0.0002**	**<.0001**	0.6779	**0.0001**