SEMINARS ON SCIENCE PEDAGOGY

FINAL REPORT

The Council of Independent Colleges

SUMMARY

Faculty teams from 19 member institutions of the Council of Independent Colleges participated in the CIC Seminars in STEM Pedagogy during Summer 2019 (in-person) and Summer 2021 (virtual). Team leaders were to report on their final outcomes by June 15, 2023. Eleven institutions submitted final reports. Six of these institutions also provided additional outcome data. No two institutions submitted the same type of data. Therefore, outcome data was not merged.

This report will describe the new pedagogies mentioned by the 11 institutions in their final reports and their written outcome statements. It will also summarize the outcomes results from the six institutions that provided data in terms of graduation status, grades (including DWF rates, or percentages of students that receive a D, receive an F, or withdraw), and concept learning. Finally, it will summarize student perceptions assessed through the Student Learning Experience Summaries (SLES) submitted by four institutions. Letters will be used to differentiate institutions throughout the report. The same institution will not have the same letter designation in different sections to maximize confidentiality.

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FINAL REPORTED PEDAGOGIES IMPLEMENTED

The 11 institutions reported using 70 different new teaching methods in their final reports. Some reports included individual reports from the faculty team members. These tended to report more strategies (up to 11 for one institution). Some institutions had brief general reports with just one or two new pedagogies mentioned. At least one institution only mentioned methods implemented since the previous year's report.

Active learning was most frequently mentioned (six of 11). Most institutions described specific active learning methods and positive general results. Some institutions presented specific results for specific pedagogies, but these were not the methods introduced in the seminar (e.g., SEA-PHAGES (Science Education Alliance - Phage Hunters Advancing Genomics and Evolutionary Science), CURE (Course-based Undergraduate Research Experience), POGIL (Process Oriented Guided Inquiry Learning)).

Table 1 shows pedagogies categorized by type, although some pedagogies could fall into two categories. Context determined in which category to place the innovation. Active learning methods accounted for 24 of the 70 mentions. Changes in homework assignments accounted for 14 of the mentions. Although only two specific technology related innovations were mentioned, many of the other new pedagogies involved technologies that were new for the faculty members.

Table 1. New Pedagogies Mentioned in Final Reports

Method	Total Mentions	Method	Total Mentions
Active Learning		**Research**	
Active Learning	6	CURE	3
Flipped Classroom	2	Creative Projects	1
Games	2	Project Based Pedagogy	1
Mystery Case Studies	2	SEA-PHAGES Lab sections	1
POGIL	2	Stand-In "Lab" Exercises (Online)	1
Think-Pair-Share questions	2	Student Initiated Design (Lab)	1
Book Club	1		
Concept Mapping	1		
Demonstrations	1		
In-Class Problem Solving	1		
Polling for Feedback	1		
Research Based Pedagogies	1		
Simulations	1		
Whiteboard Activities	1		
Homework		**Technology**	
Low-Stakes Reading Questions	4	Classpoint/Moodle	3
Collaborative Homework	1	Real-Time Assessment	1
Connect Reading Assignments	1		
Context-Rich Problems	1		
Freewriting	1		
Idea Maps	1		
Journal Article Discussions	1		
Scaffolded Lab Reports	1		
Student Generated Reading Questions	1		
Study Guides	1		
Targeted Reading Assignments	1		
Class Management		**Testing**	
Attendance/Participation	1	Learning Objectives	4
Points	1	Two-Stage Quizzing/Exams	2
Check-in Meetings	1	Real-Time Assessment	2
Curriculum Compacting	1		
Mini-Lectures	1		
Notes Worksheet	1		
Open-Stax Textbook	1		
Peer Instruction	1		
TA-Led Study Sessions	1		

FINAL GRADUATED/WITHDREW RESULTS

Two institutions reported graduation rates and withdrawal data as outcomes.

Institution A reported that more students graduated and fewer withdrew following pedagogy changes post seminar (Figure 1). The Chi-Square is not statistically significant (Chi-Square (2) = 1.88, p = .39, n = 360, Figure 1). Women showed higher graduation rates in science majors (Chi-Square (2) = 5.48, p = .06, n = 253, Figure 2). The number of men post seminar was small (n = 29) but fewer of them withdrew from college in the post-seminar conditions (Chi-Square (2) = 8.08, p = 0.017, Figure 3). The number of first generation students in the post-seminar classes is also small (n = 26). Figure 4 shows that more of them graduated and fewer withdrew (not a statistically significant difference (Chi-Square (2) = 2.08, p = 0.35).

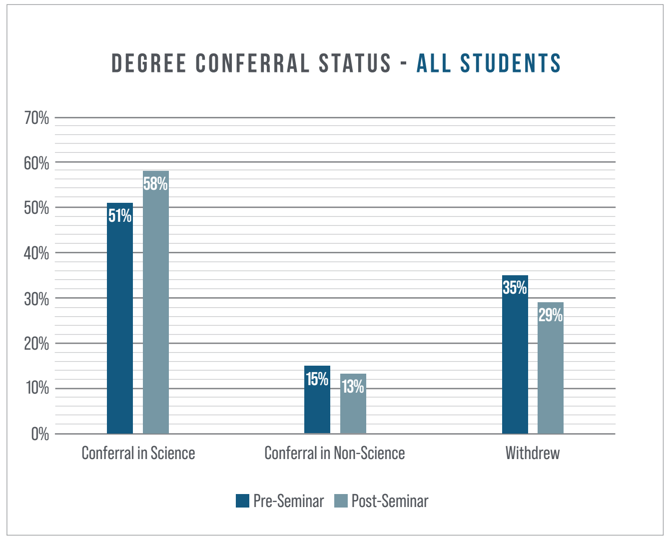

Figure 1. Students enrolled in biology after the faculty implemented pedagogy changes were more likely to graduate with a degree in sciences and less likely to withdraw (n = 360, Chi-Square not significant.)

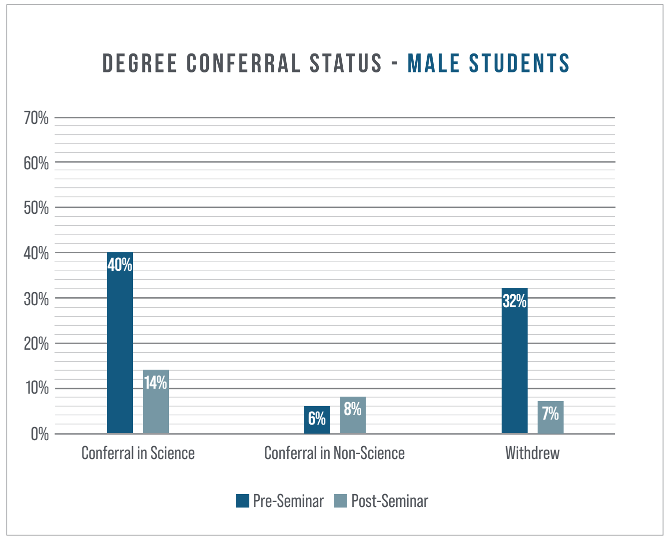

Figure 3. Degree conferral status for male students is shown in counts rather than percentages because of the small n. Nevertheless, the difference in graduation rates is striking and statistically significant. Fewer post-seminar male students graduated in science or withdrew.

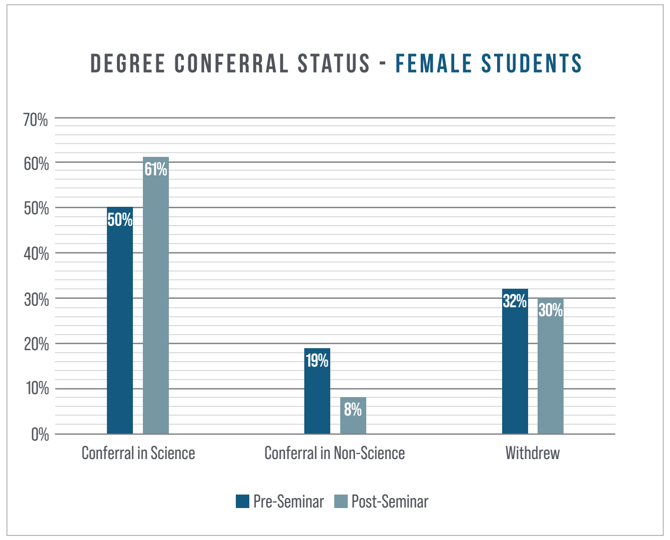

Figure 2. Women students in the introductory biology courses taught after faculty implemented new pedagogies were more likely to graduate and stay in a science major (n = 253).

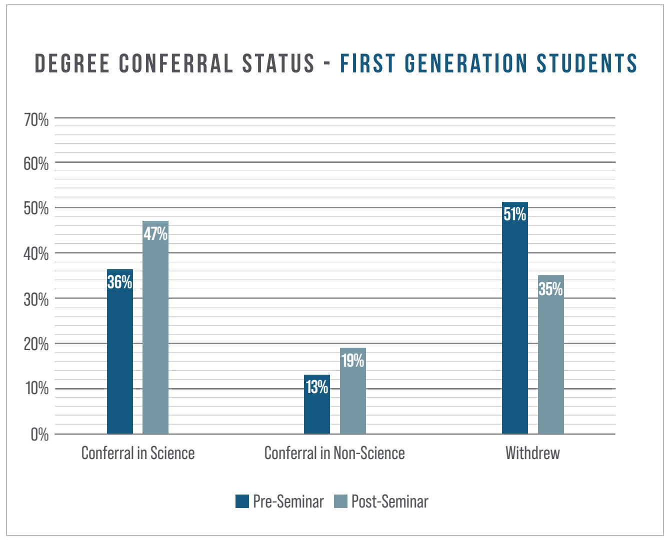

Figure 4. Degree conferral status for first generation students. These results are not significant because the n is so small (26 students post-seminar).

Institution B submitted final outcome data in a completely analyzed form. The following are excerpts of their analyses. The analyses compare students who were in the classes of seminar participants with those in the classes of control faculty. The baseline data did not include enough seminar participants' students for inclusion in the analyses. These data include students who took the introductory science classes beginning in Fall 2019 through Spring 2021 and report their status as of Spring 2022.

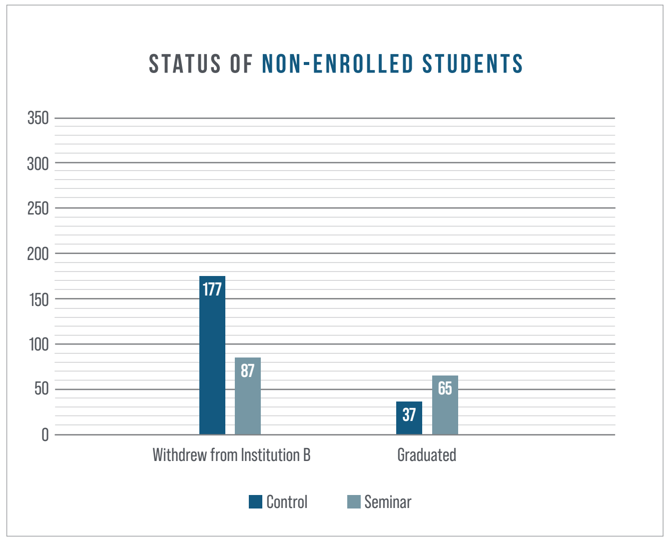

Figure 5. Attrition versus graduation rates for students not enrolled in Spring 2022 by Seminar Participation of Instructor.

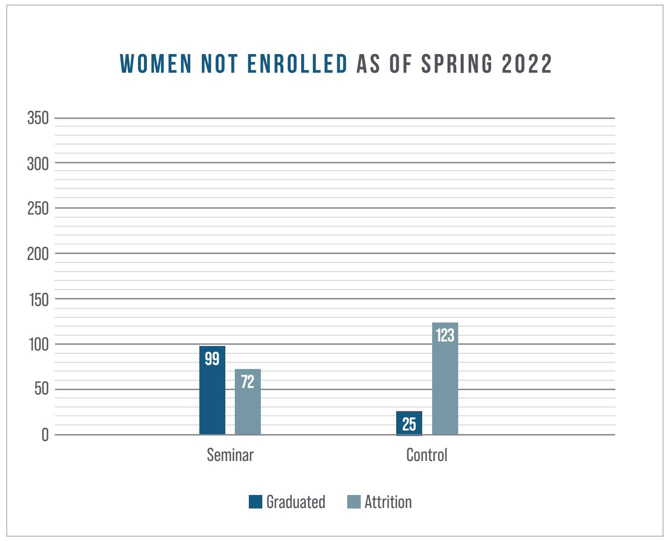

Figure 6. The n are above each column. Women in the post-seminar sections were more likely to graduate and less likely to withdraw than women in the control sections.

Of the 366 students who were no longer enrolled during Spring 2020, 28% had graduated (Figure 5). The proportion graduating was higher for students who had taken an introductory STEM course taught by a CIC Seminar in STEM Pedagogy participant (48% graduating compared to 52% attrition) than for those who had taken the same course with non-seminar instructor (Control) (17% graduating compared to 83% attrition) (Chi-Square (1) = 28.69, p <.001).

Separate analyses by gender show that the Chi-Squares are significant for each gender. Both women and men who were in the classes taught by seminar participants were more likely to graduate than those in the control sections (Figures 6 and 7). This was particularly striking for the women. Of those women who had left the college, 58% in the seminar sections had graduated compared to 17% of those in the control sections. Among the men, graduation rates were lower. Nevertheless, men in the seminar sections were still almost twice as likely to graduate (35% graduated) as those in the control sections (18%).

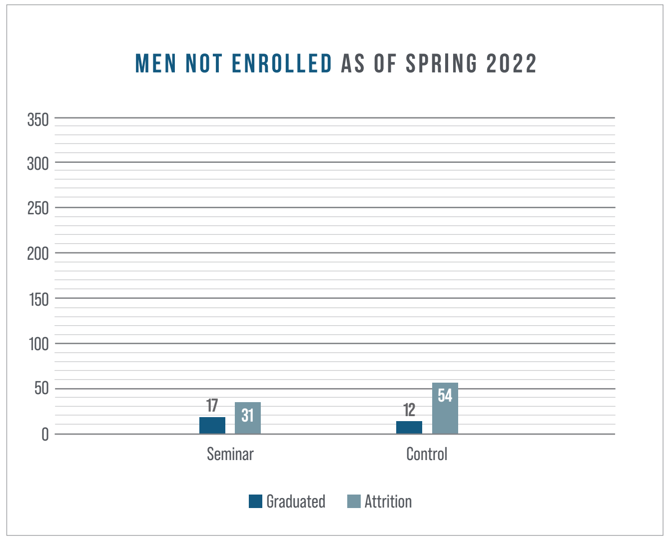

Figure 7. The n are above each column. The proportion of men who graduated was higher for those in the seminar condition than those in the control condition.

GRADES AS OUTCOMES

Institution A
Institution A reported results for course exams showing the distributions for every exam shifted in a positive direction after the seminar for a partially flipped course.

- The medians increased. This means the "middle student" in the class went from C-level work to B/B minus-level work for these exams.
- The first quartile (Q1) increased for each exam, meaning the lowest performing students did better.

In addition to the exam distributions, there were several other positive changes leading to a positive shift in overall grade distribution for these courses. The DFW rates for the partially flipped versions were low, 10% and 6% in two different courses. Attendance increased from an average of 76% for non-exam days in 2021 to 86% in 2022. The teaching evaluations for the 2022 version of the courses were positive, with some instructor scores receiving all top ratings. In all, they consider the changes to be a success, and will pursue them in future semesters.

Institution B
Course Grade. A 2x2 ANOVA (Instructor Workshop Participant x Student Gender) showed a significant main effect for instructor workshop participant ($F(1,1322) = 5.73$, $p = 0.015$). Figure 8 shows that students averaged higher grades in courses taught by seminar participants (all post-seminar) than those taught by control faculty.

Cumulative Grades. Analysis of the cumulative grades at the end of Spring 2022 term showed significant effects of instructor workshop participation ($F(1, 1108) = 22.24$, $p < .001$) and student gender ($F(1, 1108) = 3.93$, $p=.048$). The interaction had significance levels at $p = .07$. The graphs are very compelling. They show that students in the courses taught by the workshop participants had higher cumulative grades at the end of the Spring 2022 term, and that the gender difference (women higher than men) exists only for students in the control classes (Figure 9).

Figure 8. Course grades were higher for students in sections taught by workshop participants over six semesters (n = 1326).

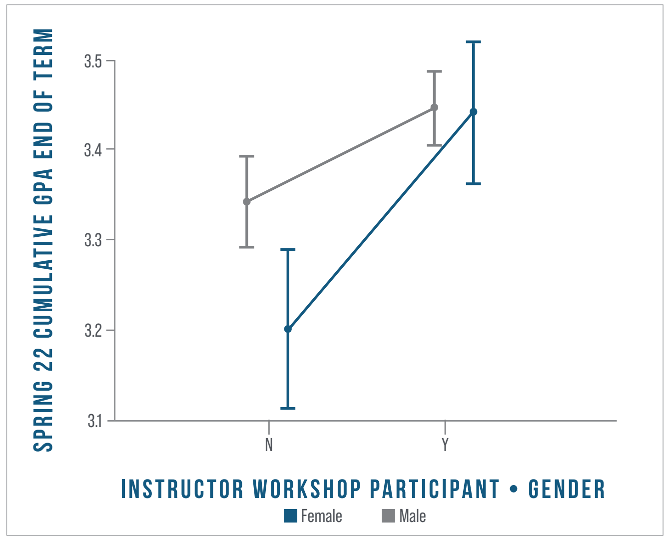

Figure 9. Spring cumulative grades were higher for women and for students taught by workshops. The gender difference in grades disappeared in courses taught by faculty members after the seminar.

Institution C
Both biology and chemistry departments implemented the CIC Seminar in STEM Pedagogy changes in all sections of their beginning courses. They reported course grades for two fall semester terms before the seminar (2019 and 2020) and two fall semester courses after the seminar (2021 and 2022).

Institution D
Assessment results for cumulative GPA and ACS (American Chemical Society) Standardized General Chemistry Final Exam scores are shown in the Table 2. Class average GPA appears to increase after the seminar but average ACS scores do not. They reported that the results should be taken with reservations because of small class sizes and changes due to COVID-19 pandemic prevented full implementation of specific new pedagogies.

Institution E
The institution implemented department-wide curricular change after the seminar. They chose to report grades for students enrolled in the traditional biology course to those with a new lab. They reported that the grades were higher and the DWF rate was lower for the students in the new lab courses. They concluded that the program was a success in terms of reduced DWF rates. The actual difference is small at about 3% points (35% new lab, 38% traditional course).

Institution G
One biology instructor reported positive changes in students' grades and attitudes following changes implemented after the seminar.

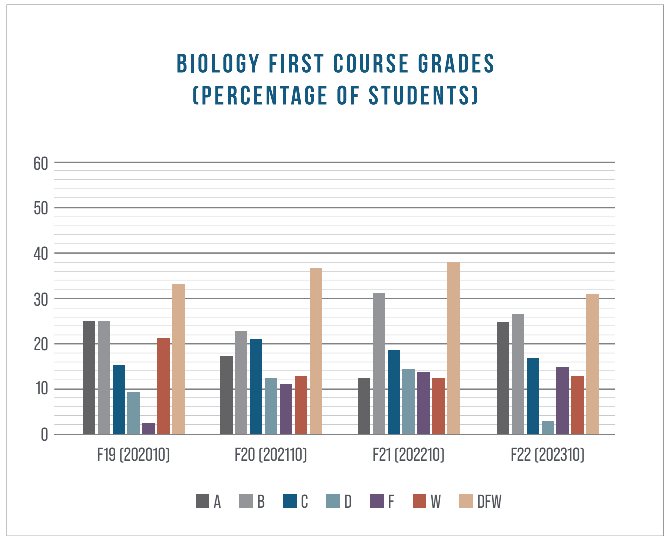

Figure 10. Introductory biology grades for the baseline (F19 and F20) and after the seminar (F21 and F22).

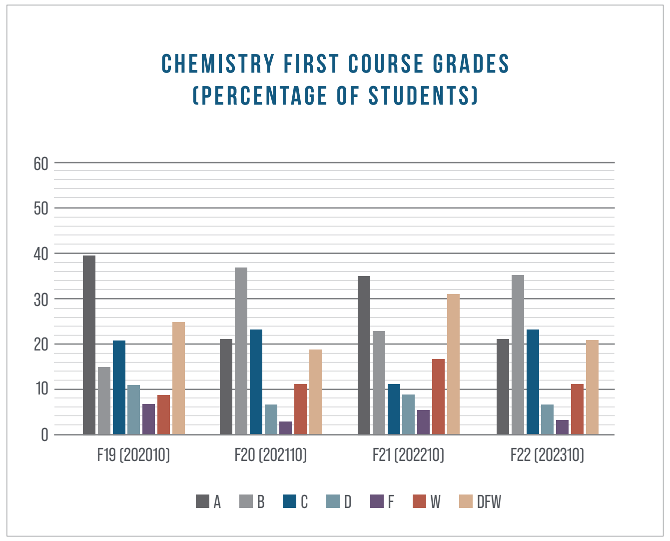

Figure 11. Introductory chemistry grades at baseline (F19 and F20) and after the seminar (F21 and F22).

The changes in biology grades do not seem to correspond to participation in the seminar because the last term presented is similar to the two terms before the seminar (Figure 10). The term immediately following the seminar had decrease in As and the following year had an increase.

Institution C also submitted data on the percentage of students who took a subsequent course in the discipline following the introductory course. There were no increases in the chemistry percentages (17%, 21%, 17% and 16%). The results for subsequent courses for the biology introduction were similar (36%, 39%. 40%, 24%). Overall, the grade data and subsequent course data show no systematic changes from pre-seminar to post-seminar.

Table 2. Grades and ACS Exam Averages by Term

Prior to Implementing New Teaching Method	Average Class GPA	Average ACS Scores (70 Max)
Fall 2013	2.85	37
Spring 2016	3.10	35
Fall 2016	2.78	35
Prior to Implementing New Teaching Method	**Average Class GPA**	**Average ACS Scores (70 Max)**
Fall 2019	3.51	37
Spring 2021	3.49	32
Spring 2022	3.05	29

CONCEPT TESTS

Institution A
Institution A biology program instituted many curricular changes after the seminar. They assessed students' pre-course knowledge compared to post course knowledge. The scores on the posttest (percent of questions right) were statistically higher ($t(375) = -12.4$, $p < .001$, Figure 12). The number of students taking the test was also different with fewer taking the posttest, partially due to attrition (pre n = 204, post n = 173). Their conclusion was, "Overall, increase in understanding of concepts! Seems the extra review and evaluations had a positive impact."

Institution B
This institution provided learning outcome data by specific course and instructor in lieu of concept inventories. They reported that the general trend was that the percentage of students meeting the learning outcomes increased between baseline and Year 1.

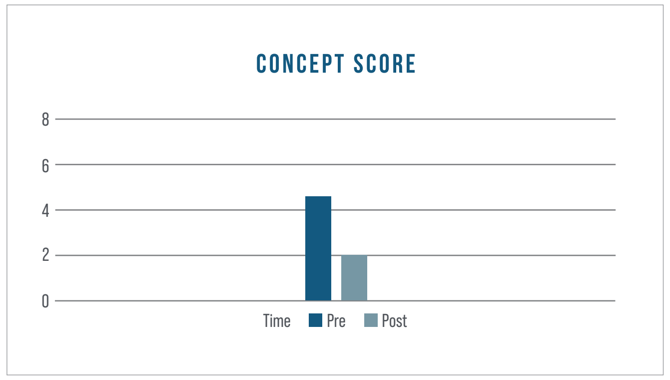

Figure 12. Concept test scores were higher for students at the end at the semester in courses with the pedagogy innovations.

STUDENT LEARNING EXPERIENCE SURVEY

Four institutions provided SLES data. The analyses are presented separately for biology and chemistry courses because of the institutional differences in comparison groups (Figure 13). There was not enough physics data to analyze (n = 12).

Course conditions are defined as:
Baseline – Before faculty members had participated in the CIC Seminar in STEM Pedagogy
Control – After the CIC Seminar in STEM Pedagogy but taught by non-participant faculty members
Seminar – Taught by faculty members after they had participated in the CIC Seminar in STEM Pedagogy

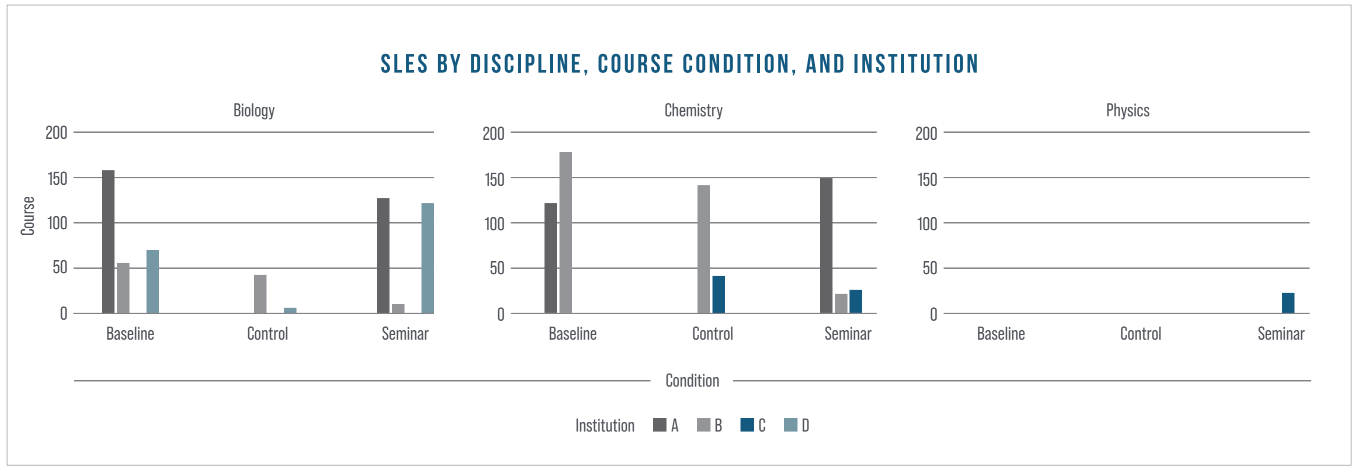

Figure 13. Institutional representation by discipline and course condition shows that for biology the baseline and seminar conditions are similar but for chemistry each condition has a unique institutional composition.

Data from students who failed to answer the validation item correctly (Q3n) were removed from the sample. In order to simplify the results each questionnaire section shows the percentages of students who rated the items as extremely or very helpful, or as not applicable. The "not applicable" responses indicate that the students did not experience a particular pedagogy or learning strategy. The data tables appendices include analyses for each item with the original rating scales for the total sample and for the biology and chemistry class samples with complete statistical analyses.

Q1. How much did information provided help you learn in this course?
The items in the first section refer to methods of receiving information that are typical for introductory science courses.

Biology Courses

Chi-Square tests of independence for each item showed statistically significant difference between the course conditions for all of the items in Question 1 except the helpfulness of the textbook (Q1d), which was rated as the least helpful of all the items equally in the three conditions. Seminar condition students rated items as helpful similar to baseline course students except that seminar condition students rated the topic list or syllabus (Q1a) slightly less helpful than did the baseline course students (Figure 14).

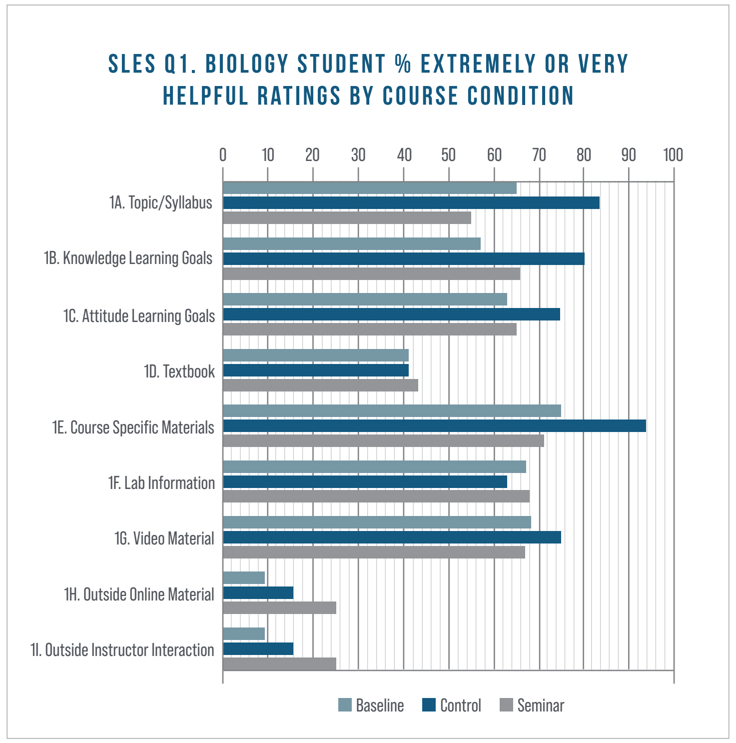

Figure 14. Biology Course SLES Q1 helpful ratings by course condition show that most items were rated helpful, and the control condition students were most likely to rate them as helpful.

Table 3 shows the "not applicable" answers by course condition. Information accompanying lab instructions (Q1f) was not applicable for one quarter of the control students indicated a major difference in the types of courses they were rating.

Table 3. Biology SLES Q1 Not Applicable Responses

Biology	Not Applicable %		
SLES Q1	Baseline	Control	Seminar
1A. Topic/List Syllabus	1	0	0
1B. Knowledge Learning Goals	0	0	0
1C. Attitude Learning Goals	0	2	0
1D. Textbook	1	0	3
1E. Course Specific Materials	5	2	6
1F. Lab Information	2	25	0
1G. Video Material	2	2	0
1H. Outside Online Content	2	8	2
1I. Outside Instructor Interaction	14	15	6

Chemistry Courses

Most of the Q1 items showed statistically significant Chi-Squares for the chemistry courses ratings. However, the patterns are not as consistent as for the biology courses (Figure 15). Students in the control courses were most likely to rate the attitude learning goal (Q1c) higher than students in the seminar course. Students in the seminar conditions were more likely to rate information accompanying lab instructions (Q1f) as helpful compared to the control condition.

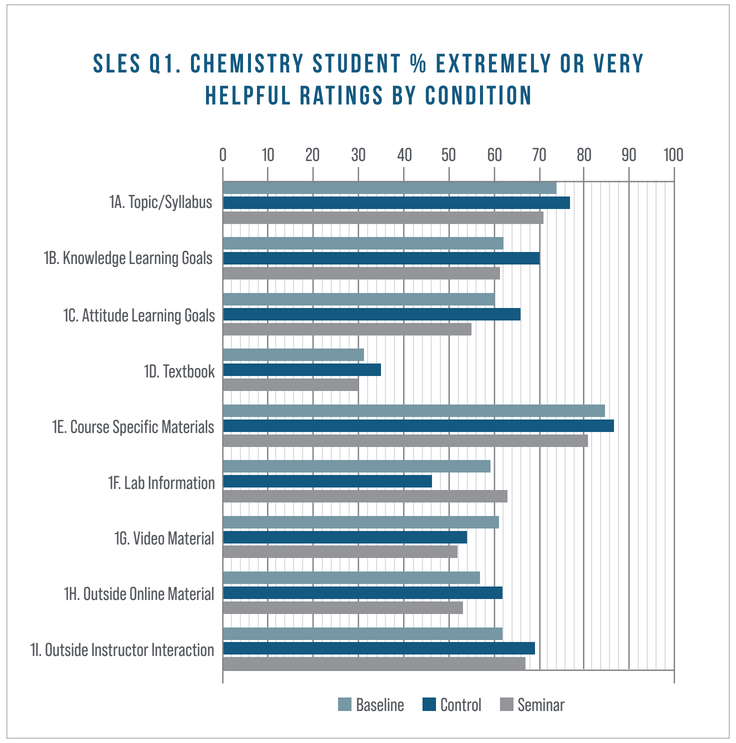

Figure 15. Chemistry course helpfulness ratings showed small differences among the course conditions, although all are statistically significant.

Some of the significant differences between conditions were due to the not applicable responses (Table 4). Students in the baseline and control condition (33%) were more likely to mark lab materials (Q1f) as not applicable. The control condition was also likely to mark video material (Q1g.) as not applicable.

Table 4. Chemistry SLES Q1 Not Applicable Responses

Chemistry	Not Applicable %		
SLES Q1	Baseline	Control	Seminar
1A. Topic/List Syllabus	2	3	6
1B. Knowledge Learning Goals	0	0	1
1C. Attitude Learning Goals	2	0	1
1D. Textbook	7	9	8
1E. Course Specific Materials	5	2	1
1F. Lab Information	21	33	3
1G. Video Material	13	22	9
1H. Outside Online Content	10	10	7
1H. Outside Instructor Interaction	20	13	4

Q2. How much did various types of homework help you learn this course?
The items in this section relate to specific types of homework and classroom activities. The CIC Seminar in STEM Pedagogy covered most of these types of activities.

Biology
Table 5 shows that there were statistically significant Chi-Squares for each item in SLES section 2. In contrast to Question 1 which showed similarities in general course ratings between the baseline and seminar conditions, these analyses show that the seminar condition students rated clicker questions (Q2c), discussion of clicker questions with other students (Q2d), and in-class activities in groups using worksheets or other resources (Q2f) as more helpful than did the other students. Table 5 and Figure 16 both show these results because of the relevance of Question 2 to the CIC Seminar in STEM Pedagogy goals.

Table 5. Biology SLES Q2 Helpful % Responses

Biology	Extremely or Very Helpful %			
SLES Q2	Baseline	Control	Seminar	Sig.
2A. Lecture Presentations in Class	69	83	77	*
2B. “Socratic Dialogues”	46	56	59	*
2C. Discussion ... Important	63	75	68	*
2D. Clicker Questions	41	17	75	*
2E. Discuss Clicker Questions	33	13	55	*
2F. In-class Activities	54	42	69	*
2G. Non-clicker Questions	45	55	51	*
2H. Whole Class Discussions	53	47	58	*
2I. Demonstrations/Animations	75	77	78	*
2J. Discuss Demonstrations	68	69	76	*
2K. Assess Peers’ Work	41	37	45	*
2L. Help from TA	49	17	53	*
2M. Help from Instructor	75	82	81	*

Table 6. Biology SLES Q2 Not Applicable Responses

Biology	Not Applicable %		
SLES Q2	Baseline	Control	Seminar
2A. Lecture Presentations in Class	2	4	0
2B. “Socratic Dialogues”	7	17	1
2C. Discussion ... Important	2	8	1
2D. Clicker Questions	25	74	4
2E. Discussion Clicker Questions	25	74	5
2F. In-class Activities	10	6	1
2G. Non-clicker Questions	9	18	3
2H. Whole Class Discussion	9	39	6
2I. Demonstrations/Animations	3	18	0
2J. Discuss Demonstrations	5	20	2
2K. Assess Peers’ Work	10	44	5
2L. Help from TA	15	74	3
2M. Help from Instructor	3	10	0

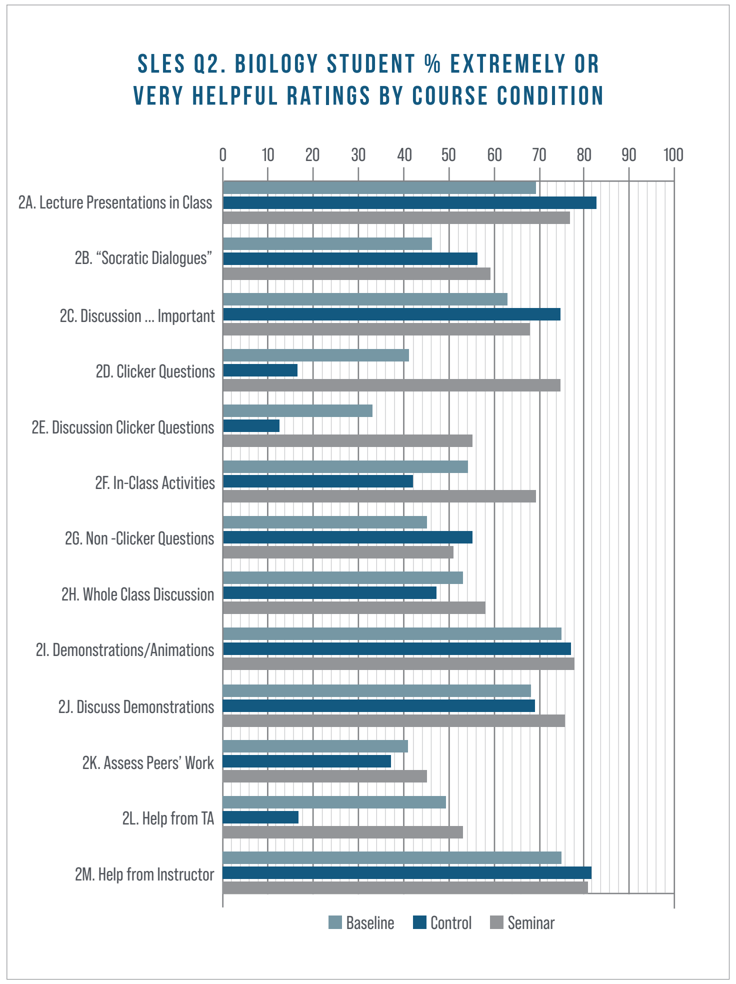

Figure 16. Biology SLES Q2 helpful responses show rated clicker activities and in class activities were highest among students in the seminar condition.

Some of the significant differences between the course conditions in Question 2 items were due to the “not applicable” responses. These indicate that students in the seminar condition are more likely to experience the full variety of homework and course activities than are those in the control and baseline conditions. Specifically, Table 6 shows the modal response for the control group for many of the items was “not applicable.”

Chemistry

The chemistry course student ratings showed that students in the seminar sections were more likely to experience more varieties of homework and class experience and in particular that they were more likely to rate clicker questions (Q2d), discussions with other students about clicker questions (Q2e), and in-class activities (Q2f) as helpful. They were also more likely to rate help from a TA (Q2l) as available and helpful (Table 7 and Figure 17).

Table 7. Chemistry SLES Q2 Helpful % Responses

Chemistry	Extremely or Very Helpful %			
SLES Q2	Baseline	Control	Seminar	Sig.
2A. Lecture Presentations in Class	74	79	74	*
2B. "Socratic Dialogues"	56	62	51	*
2C. Discussion ... Important	61	69	52	*
2D. Clicker Questions	38	46	58	*
2E. Discuss Clicker Questions	27	34	48	*
2F. In-class Activities	50	51	71	*
2G. Non-clicker Questions	50	64	45	*
2H. Whole Class Discussions	47	59	47	*
2I. Demonstrations/Animations	59	67	61	*
2J. Discuss Demonstrations	59	73	61	*
2K. Assess Peers' Work	35	40	31	*
2L. Help from TA	31	28	55	*
2M. Help from Instructor	77	80	79	*

Table 8. Chemistry SLES Q2 Not Applicable Responses

Chemistry	Not Applicable %		
SLES Q2	Baseline	Control	Seminar
2A. Lecture Presentations in Class	5	0	0
2B. "Socratic Dialogues"	11	8	10
2C. Discussion ... Important	6	4	5
2D. Clicker Questions	35	31	21
2E. Discussion Clicker Questions	42	36	26
2F. In-class Activities	21	31	8
2G. Non-clicker Questions	12	12	4
2H. Whole Class Discussion	25	21	23
2I. Demonstrations/Animations	12	12	10
2J. Discuss Demonstrations	15	11	9
2K. Assess Peers' Work	40	37	28
2L. Help from TA	40	53	14
2M. Help from Instructor	5	4	0

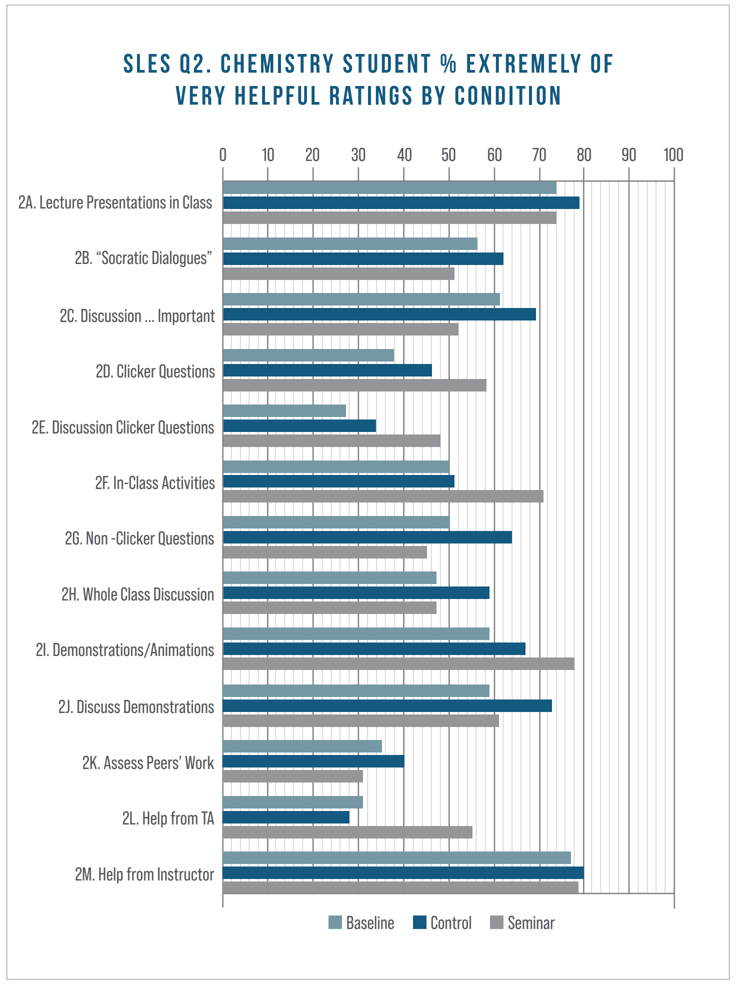

Figure 17. Chemistry SLES Q2 helpful ratings showed that the seminar students were more likely to rate clicker questions, clicker discussions, in class activities, and help from a TA as helpful.

The control and baseline students were more likely to rate many items as not applicable (Table 8).

Q3: How much did various types of homework help you learn in this course?
The items in this section related to various types of homework common in introductory science classes. The CIC Seminar in STEM Pedagogy explicitly addressed many of them.

Biology
The statistical analysis by Chi-Square test of independence between course condition and item responses showed significance for all items except 3e (Table 9 and Figure 18), "Projects you did on your own (written, oral, poster, etc.)." Only one item showed a large difference between the baseline and treatment conditions. Students in the courses taught after their faculty participated in the seminar were more likely to rate item Q3h, "Feedback from instructors or TAs on preliminary versions of work BEFORE final due date."

Table 9. Biology SLES Q3 Helpful % Responses

Biology	Extremely or Very Helpful %			
SLES Q3	Baseline	Control	Seminar	Sig.
3A. Readings Before Class	49	29	43	*
3B. Readings Sci/Prof Lit	32	37	29	*
3C. Recommend Readings	24	29	26	*
3D. Homework Exercises	52	65	61	*
3E. Project Did on Own	51	61	48	*
3F. Projects with Others	41	12	42	*
3G. Reflection on Learning	31	35	42	*
3H. Feedback Before Due Date	58	49	68	*
3I. Feedback on Completed	61	61	61	*
3J. Quiz and Exam Feedback	68	62	66	*
3K. Studying Review on Own	65	88	75	*
3L. Studying/Review Group	59	48	59	*
3M. Online Quiz/Assign.	68	84	64	*
3N. Online Wiki/Discussion	23	23	31	*
3O. Practice Questions Before	70	48	73	*
3P. Lab Related Homework	60	49	67	*

Table 10. Biology SLES Q3 Not Applicable

Biology	Not Applicable %		
SLES Q3	Baseline	Control	Seminar
3A. Readings Before Class	6	50	5
3B. Readings Sci/Prof Lit	15	43	9
3C. Recommend Readings	19	45	11
3D. Homework Exercises	5	17	3
3E. Project Did on Own	13	12	9
3F. Projects with Others	14	71	11
3G. Reflection on Learning	28	52	7
3H. Feedback Before Due Date	13	47	6
3I. Feedback on Completed	9	27	7
3J. Quiz and Exam Feedback	4	15	2
3K. Studying Review on Own	7	2	3
3L. Studying/Review Group	9	27	6
3M. Online Quiz/Assign.	3	0	1
3N. Online Wiki/Discussion	34	58	22
3O. Practice Questions Before	9	41	1
3P. Lab Related Homework	5	30	2

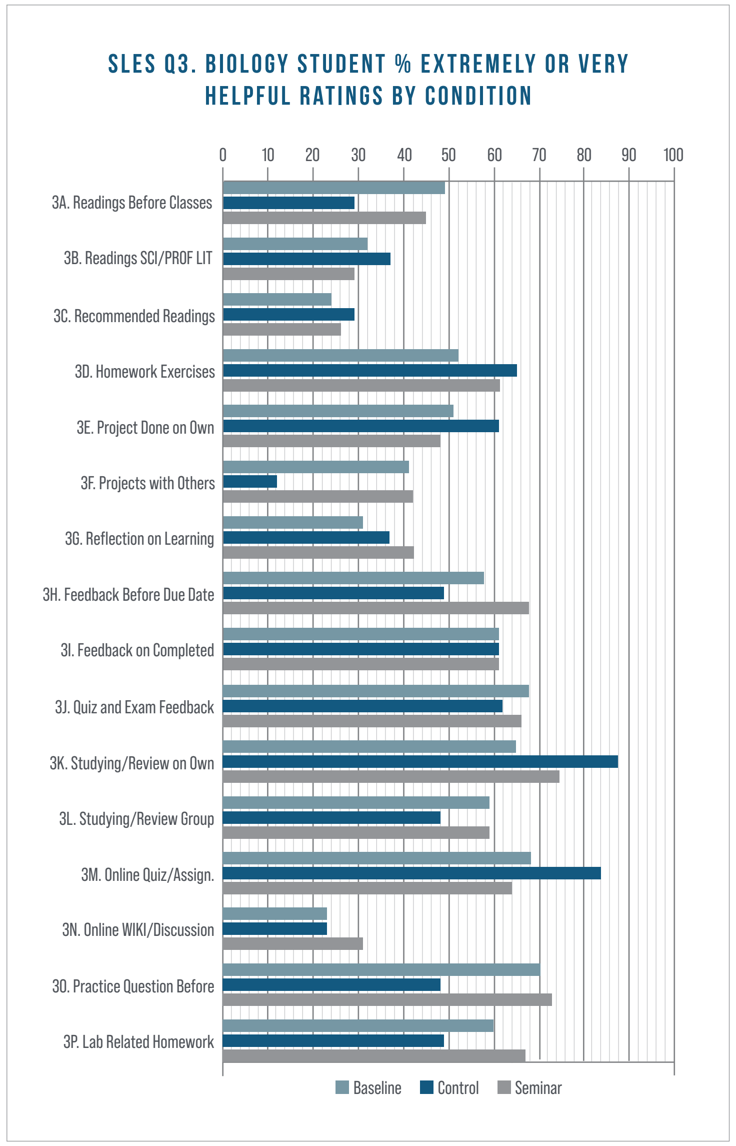

Figure 18. Biology SLES Q3 helpful ratings show general similarity between the baseline and seminar condition students.

The pattern of differences for the other items were mostly due to the control course condition students being more likely than the others to indicate that the item was "not applicable" (Table 10). The control condition students were likely to find strategies help if they were applicable. The not applicable was the control condition modal response for readings (items Q3a, Q3b, Q3c) and all other forms of active learning. There were few not applicable responses for the seminar condition students indicating that they had a larger number of learning strategies applied in their courses.

Chemistry
Eleven of the 16 items on Question 3 produced significant Chi-Square statistics. Most of these were due to differences between the control condition students and those in the other two conditions. Although reading scientific literature (Q3b) and projects alone (Q3e) or with others (Q3f) were not rated as extremely or very helpful by many students, they did get those ratings by about a quarter of the control condition students (Table 11 and Figure 19).

Table 11. Chemistry SLES Q3 Helpful Ratings

Chemistry	Extremely or Very Helpful %			
SLES Q3	Baseline	Control	Seminar	Sig.
3A. Readings Before Class	42	39	40	*
3B. Readings Sci/Prof Lit	17	27	13	*
3C. Recommend Readings	21	27	18	*
3D. Homework Exercises	79	76	78	*
3E. Project Did on Own	17	27	9	*
3F. Projects with Others	18	28	11	*
3G. Reflection on Learning	27	35	29	*
3H. Feedback Before Due Date	41	52	46	*
3I. Feedback on Completed	48	53	50	*
3J. Quiz and Exam Feedback	67	75	69	*
3K. Studying Review on Own	75	79	82	*
3L. Studying/Review Group	55	64	60	*
3M. Online Quiz/Assign.	71	71	70	*
3N. Online Wiki/Discussion	15	19	4	*
3O. Practice Questions Before	76	83	68	*
3P. Lab Related Homework	55	50	61	*

Table 12. Biology SLES Q3 Not Applicable Ratings

Biology	Not Applicable %		
SLES Q3	Baseline	Control	Seminar
3A. Readings Before Class	21	28	11
3B. Readings Sci/Prof Lit	40	39	31
3C. Recommend Readings	43	40	35
3D. Homework Exercises	0	0	1
3E. Project Did on Own	65	51	66
3F. Projects with Others	69	53	67
3G. Reflection on Learning	55	40	32
3H. Feedback Before Due Date	40	36	27
3I. Feedback on Completed	30	28	15
3J. Quiz and Exam Feedback	9	5	5
3K. Studying Review on Own	0	0	0
3L. Studying/Review Group	21	13	11
3M. Online Quiz/Assign.	2	1	3
3N. Online Wiki/Discussion	65	57	67
3O. Practice Questions Before	6	3	9
3P. Lab Related Homework	17	30	7

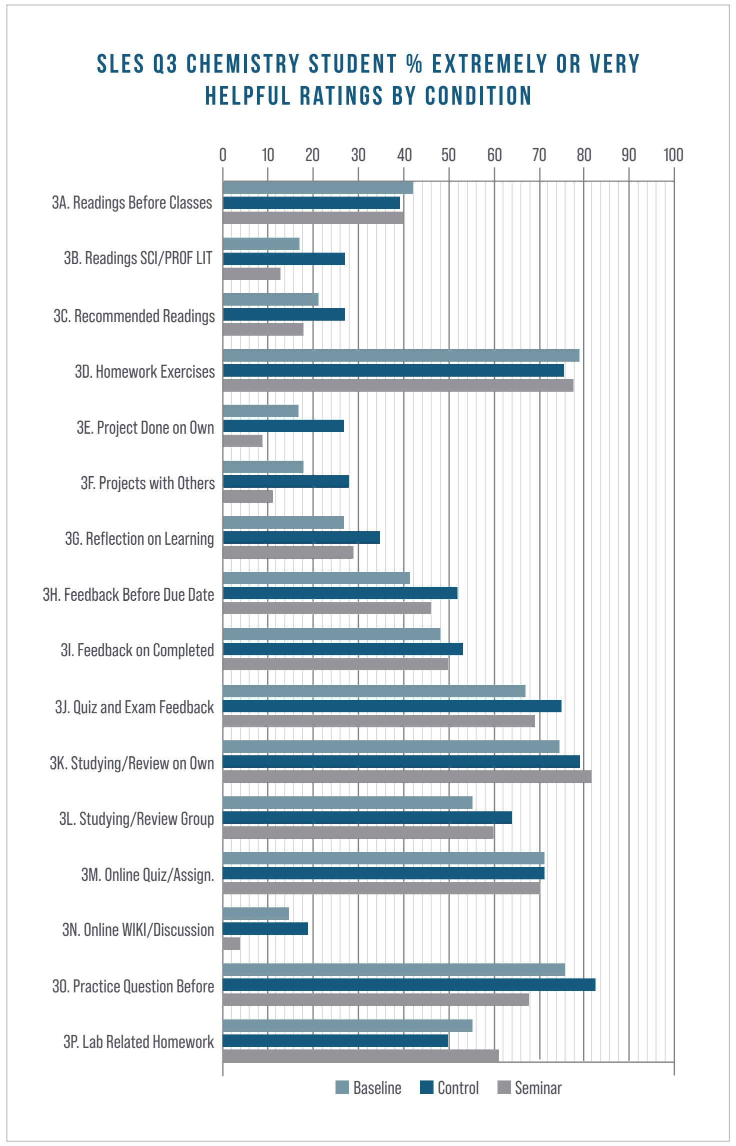

Figure 19. Biology SLES Q3 helpful ratings showed small differences.

As in the previous analyses, the "not applicable" ratings were responsible for most of the statistically significant results (Table 12). For most items, the control condition students and/or the baseline condition students were more likely to mark "not applicable" (Q3a, Q3b, Q3g, Q3h, Q3i, and Q3r). This seems to indicate that students in the seminar condition used more active learning study strategies than those in the other conditions. However, for some items they are similar to the baseline students in likelihood to rate a strategy as not applicable (e.g., Q3e, Q3f, Q3p). In general, the chemistry students in the seminar condition seemed to experience more types of learning strategies and/or activities with the exceptions of projects and online discussions. Baseline and control students were less likely to experience active learning strategies such as preliminary or post feedback, reflection, or readings.

Q4. Other opinions about this course: How much do you agree or disagree with the following?
The final five items were attitudinal. Students were asked to indicate whether they strongly agreed, agreed, were neutral, disagreed, or the item was not applicable. The first two items are about the general nature of the course and have agreement ratings from almost all of the students (few not applicable responses). Therefore, it was possible to complete ANOVAs on them. The items were coded strongly agree = 1, agree = 2, neutral = 3, and disagree = 4. Thus, lower averages indicate greater agreement.

Item 4a. Relationships between stated learning goals, course content, and required work were clear.

Biology
Biology students showed a significant main effect for condition on this item ($F(2,140) = 11.44$, $p < .001$). As shown in the Figure 20, the baseline and control students agreed less strongly on average with this statement.

Chemistry
The chemistry students in the seminar condition averaged lower agreement with the statement that the relationships between stated learning goals, course content & required work were clear ($F(2, 301) = 9.37$, $p < ,001$, Figure 21). This may indicate that the instructors made changes in the course during the semester as a result of things they learned in the seminar.

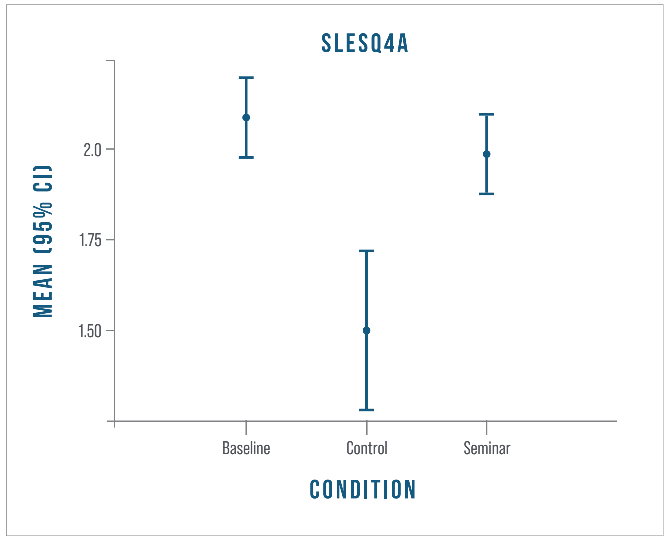

Figure 20. Students in the baseline and seminar conditions averaged lower agreement that the course matched its stated goals.

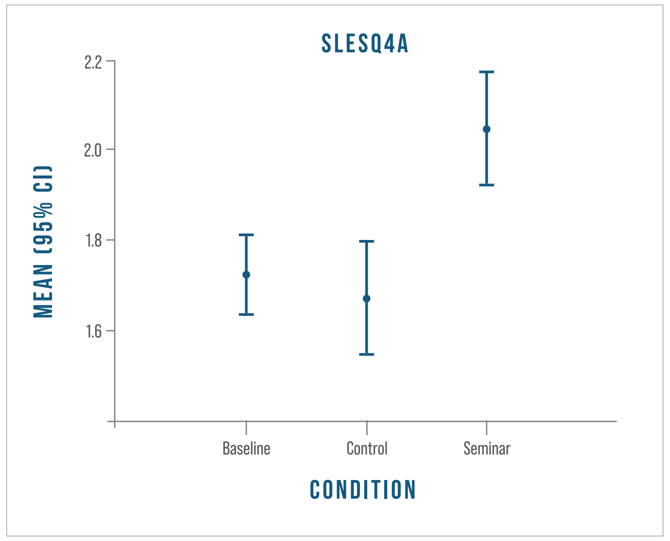

Figure 21. Chemistry course students in the seminar condition averaged lower agreement with the statment that the course matched the stated goals.

Item 4b. Knowledge and skills that I am improving in this course are important to me or my degree.

Biology
Item Q4b showed similar results to Q4a for the biology students ($F(2, 127) = 3.95$, $p = .022$, Figure 22). The baseline and seminar students showed lower average agreement with the statement, "Knowledge & skills that I am improving in this course are important to me or my degree." These findings probably result from the similarity of institutional setting and specific course between the biology baseline and seminar conditions.

Chemistry
The chemistry students' agreement with Q4b was similar to the biology student ratings. Those in the seminar and baseline and seminar groups were likely to agree less with the importance of the knowledge they were getting in the course than those in the control condition ($F(2, 308) = 5.55$, $p = .004$, Figure 23).

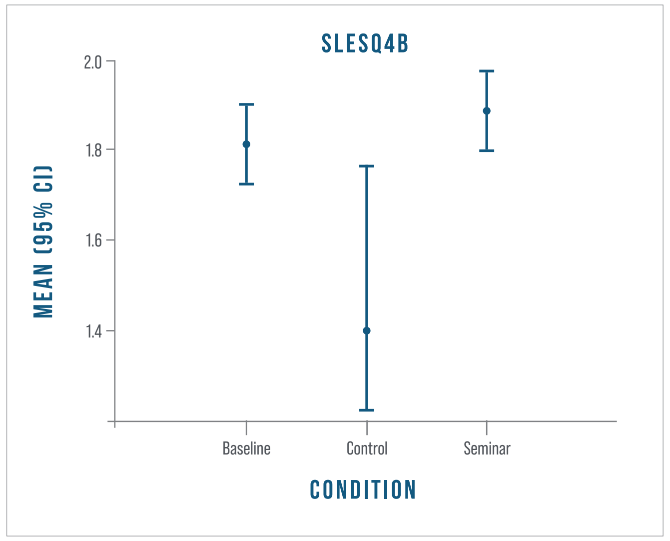

Figure 22. Biology students in the control group averaged highest agreement that the course was important.

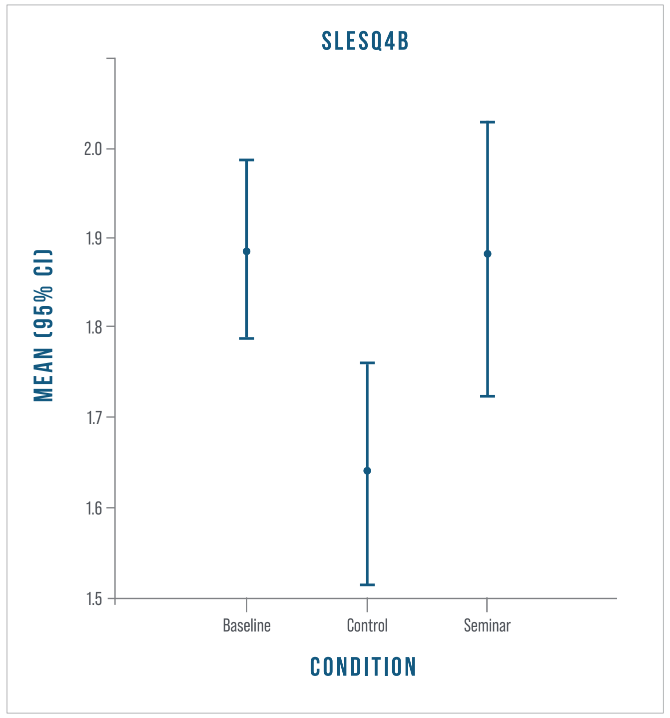

Figure 23. Chemistry students in the control condition agreed, on average, most strongly that the course was important.

Q4c. I could have learned everything in this course entirely on my own.

Biology
The ANOVA, after the not applicable responses had been set to missing, failed to show a significant effect of condition ($p = 0.057$, Figure 24). Most of the students disagreed with this statement.

Chemistry
The not applicable responses were coded as missing. Seminar students agree most on average with this statement than do those in the control and baseline conditions ($F(2, 261) = 8.55$, $p < .001$, Figure 25). While half of the seminar students disagreed that they could have learned everything in the course on their own, over 1/5th strongly agreed that they could have done so.

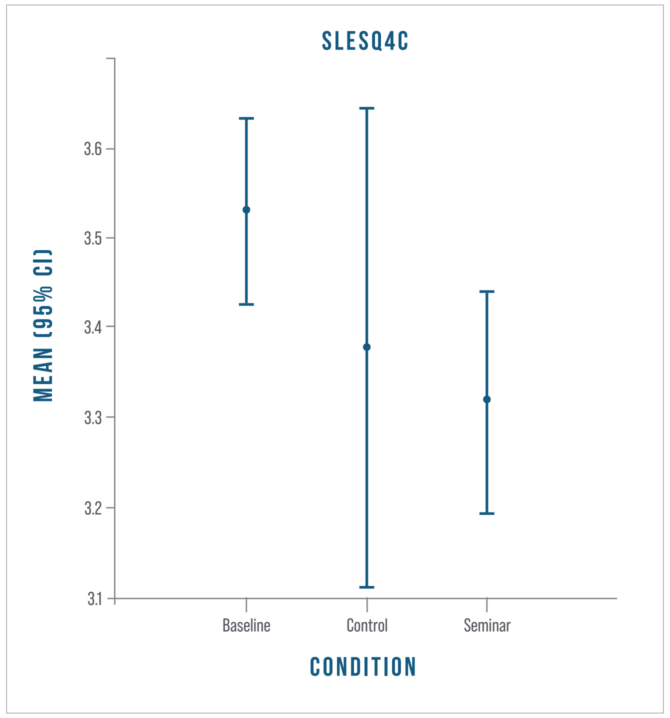

Figure 24. There was no difference among the course condition students on agreeing that they could have learned everything on their own.

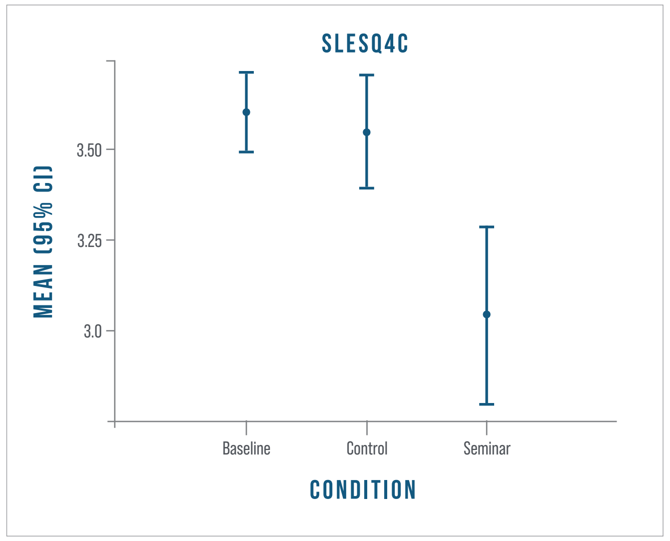

Figure 25. Chemistry class students in the seminar were averaged more agreement that they could have learned everything on their own.

Q4d and Q4e. Lab Related Items

Biology
Attitudes about labs were equivalent for the biology baseline and seminar conditions. The statistical effects were due to the large proportion of control students who rated lab questions as not applicable (around half). The biology students who had labs tended to agree that they learned a lot in them (Q4d) and disagree that the workload was too heavy for the benefit of the lab (Q4e) (Figures 26 and 27).

Chemistry
About half of the chemistry control students and 1/5th of the baseline chemistry students rated the lab questions as not applicable. Of those who had labs, they were likely to disagree that lab was where they learned the most (Q4d, Figure 28) and they also to disagree that the workload was too heavy for the benefit given by lab (Q4e, Figure 29).

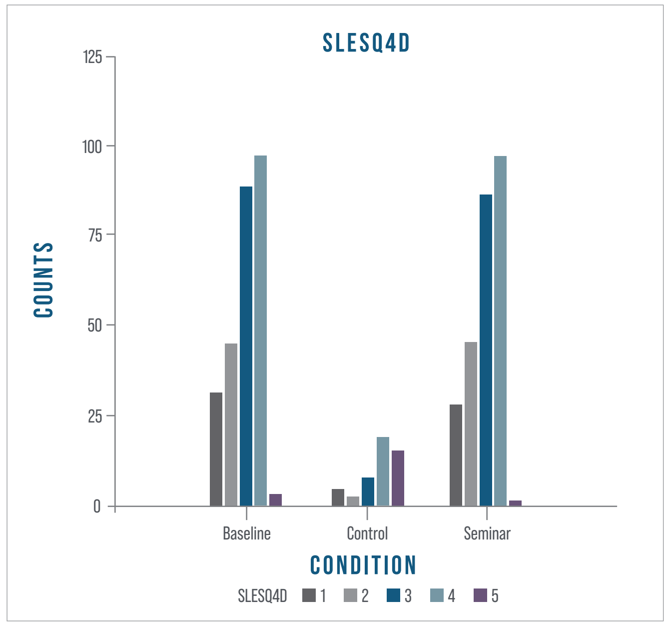

Figure 26. Biology class students in the seminar were averaged more agreement that they could have learned everything on their own.

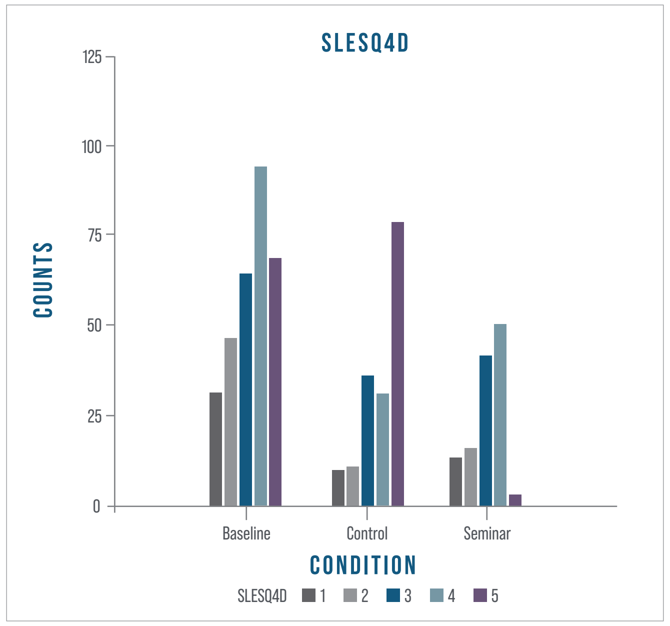

Figure 28. Chemistry students who had labs tended to disagree that labs were where they learned the most.

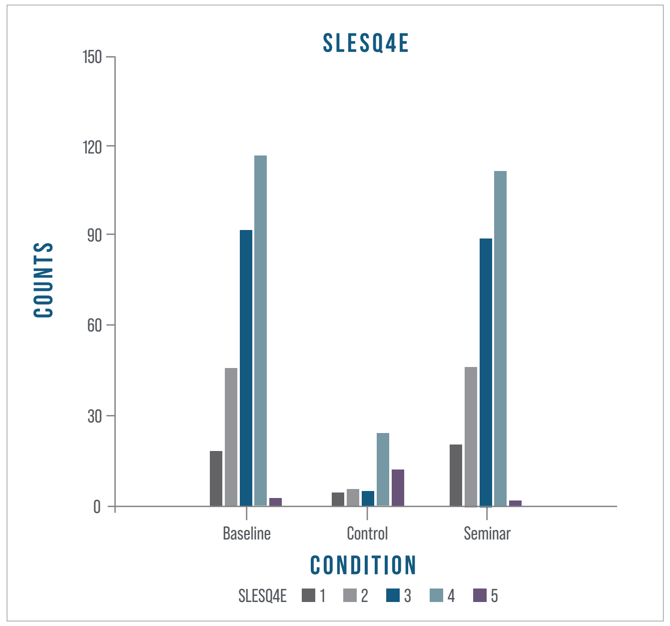

Figure 27. Biology students who had labs tended to disagree that lab workloads were too heavy.

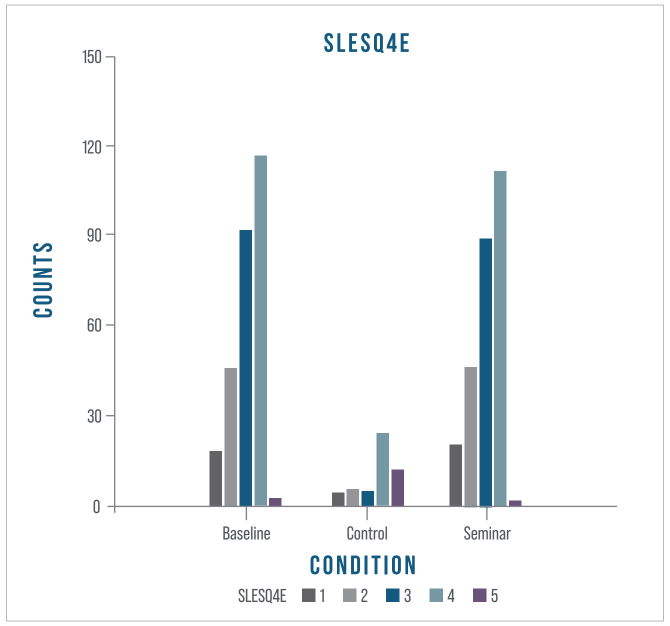

Figure 29. Chemistry students who had labs tended to disagree that lab workloads were too heavy.

APPENDIX

Resources from the CIC Seminars on Science Pedagogy

Below is a list of suggested readings and materials for the CIC Seminars on Science Pedagogy.

The following helpful materials are drawn from a collection at http://cwsei.ubc.ca/resources/instructor_guidance.htm:

Assessments That Support Student Learning: http://cwsei.ubc.ca/resources/files/Assessment_That_Support_Learning.pdf

Clicker User's Guide: http://cwsei.ubc.ca/resources/files/Clicker_guide_CWSEI_CU-SEI.pdf (and more at http://cwsei.ubc.ca/resources/clickers.htm)

Creating and implementing in-class activities; principles and practical tips: http://cwsei.ubc.ca/resources/files/InClassActivities-tips_CWSEI.pdf

Group Work in Educational Settings: http://cwsei.ubc.ca/resources/files/Group_work_SEI_8-08.pdf

The videos collection is: http://cwsei.ubc.ca/resources/SEI_video.html

Physics PhET simulations https://phet.colorado.edu/en/simulations/category/new

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