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Through the Looking CLASS: When Peer Leader Learning Attitudes Are Not What They Seem

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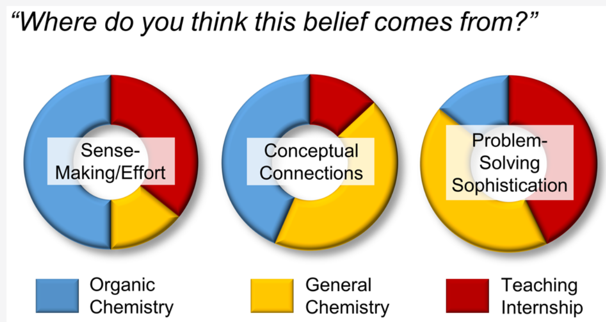

ABSTRACT: The Teaching Internship is a credit-bearing program composed of undergraduate near peer instructors (teaching interns, or TIs) that offers supplemental assistance for students in the General Chemistry courses. With fellow undergraduates serving as a role model and student−faculty liaison, the benefits of near peer instruction have been well-documented. Because TIs develop a dual role of student and instructor over time, they afford a unique opportunity to explore the middle area of the expert/novice spectrum. Identifying the most influential components of the TI role may allow practitioners to implement these components in other ways for different groups of students. The present work provides a description of the TI model and uses a mixed-methods approach to analyze how the peer leadership role impacted the TIs’ attitudes about learning chemistry. Quantitative results show that TIs do hold predominantly expert-like learning attitudes compared to the General Chemistry population from which they are selected; however, evidence of novice thinking is still observed in some areas. This survey data was then used to inform a qualitative approach. Further analysis indicated that TIs’ responses on survey items were context-dependent, and that peer leadership experiences were associated with expert learning attitudes and appear to be influential in the development of these attitudes. These findings suggest that these factors should be taken into account when drawing general conclusions from survey results.

KEYWORDS: *First-Year Undergraduate/General, Chemical Education Research, Collaborative/Cooperative Learning, Constructivism, Student-Centered Learning, TA Training/Orientation*

FEATURE: Chemical Education Research

■ INTRODUCTION

Rising university enrollments in the STEM fields have outpaced the moderate growth in higher education funding,[1,2] leading to increasing concerns about sustainability and student learning.[3−7] Recent calls for a larger, more diversified STEM work force highlight the need for educational reforms.[8] So-called “near peer” instruction has been one means for mending the resource gap, cementing itself as a critical component of the teaching and learning infrastructure in higher education. Previous studies have demonstrated the many benefits to students on the receiving end of near peer instruction,[9] but fewer studies have reported the impact on the peer instructors themselves.[7]

The present study aimed to quantify and describe how the peer leadership role in the Rutgers General Chemistry Teaching Internship program has influenced the teaching interns’ (TIs’) beliefs about learning in real time. Our original strategy was to explore the use of the Colorado Learning Attitudes about Science Survey (CLASS),[10] an instrument that has been validated and used in other contexts. We found, however, that the TIs’ responses were highly context-dependent, and delving deeper, we collected extensive qualitative data that shed light on the origin of novice and expert shifts in attitudes. We found that TI shifts toward expert attitudes were most profoundly correlated with their experience as a peer leader; in fact, there were no instances in which novice shifts in attitude were associated with this context.

The paper is outlined as follows: The next section provides a brief summary of the relevant literature on peer and near peer instruction, as well as the motivation for this work. Following this, a description of the TI program establishes the context of the study, and the key research questions are developed from a framework of situated learning. The Methods section provides a detailed description of the data sets collected and their analysis. The Results and Discussion sections then present the analysis in order to sequentially answer each research question

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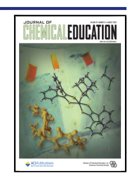

outlined earlier. The paper closes with a summary of limitations, overarching conclusions, and implications for researchers and practitioners.

LITERATURE REVIEW

Defining (Near) Peer Instruction

A quick search of the literature shows that peer instruction and its close relative, near peer instruction, are becoming a standard practice within higher education.[9] Cited as a means to compete with increasing admissions and changes to the student populations,[9,11−13] this practice also serves as an homage to the shift toward active learning.[14−17] Peer instruction was first named by Eric Mazur as a means of engaging all students in large-enrollment courses.[18] In lecture, students explained their reasoning for a given conceptual problem (a ConcepTest) to others in their vicinity. The "peers" are other students enrolled in the class. Near peers, on the other hand, are experienced students who have successfully completed a course and return to teach current students. Murphey first coined the term "near peer", describing them as "...peers who are close to one's social, professional, and/or age level, and whom one may respect and admire".[19,20]

Singh outlines some of the major differences between peers and near peers in her commentary, primarily contrasting students' perceptions of their peers versus their near peers.[21] Still, the two terms are often used interchangeably in the literature, with both falling under the "peer" umbrella, and countless nuanced terms only add to the confusion: peer mentor,[13] peer tutor,[22] peer assistant,[16] peer facilitator,[23,24] peer leader,[25−27] etc., in addition to others (e.g., undergraduate teaching assistant,[28−32] learning assistant,[33] teaching intern,[25] etc.). Even within a given term, the duties or goals of these peers/near peers can look vastly different among departments, universities, and disciplines.

Such inconsistent use of terminology in the literature can lead to a considerable lack of clarity in discussions. For the purpose of this paper and the various programs described, we define "peer leader" as follows:

> *An undergraduate student acting in a mentorship or instructive role for other undergraduate students in a course or program for which they themselves were previously enrolled.*

The authors felt that the term "peer leader" was most inclusive, consistent with current literature, and properly conveyed the experience and facilitative nature of the students acting in these roles.

Peer Leadership: History and Outcomes

In the 1970s, sudden demographic changes, climbing attrition rates, and scarce resources catalyzed a movement that resulted in the earliest standardized model of peer leadership: Supplemental Instruction, or SI.[4,34] Deanna Martin, a doctoral student at the time, proposed the SI model as a stark contrast to previous remedial-focused efforts that were being phased out nationwide.[4,35] Later programs like peer-led team learning (PLTL)[17] and the learning assistant (LA) program[33] further helped to popularize the idea of peer leadership in the 1990s and early 2000s. There have since been countless models of peer leadership described in detail in the literature and implemented nationally and internationally.[7]

In accordance with the expansion of this practice, numerous researchers have examined the outcomes of peer leadership in courses such as physics,[36,37] computer science,[38] engineering,[39,40] chemistry,[12,15,41−44] social sciences,[11,31,45] life sciences and medicine,[14,28,32,46,47] and the humanities.[48,49] Emerging benefits include both content gains (pass rates,[12] retention,[42] and exam scores[33,41,42]) and noncontent gains (attitudes[42,43] and communication skills[50]) for students served by peer leaders. However, only a handful of studies have aimed to characterize the effects of peer leadership experience on the peer leaders themselves. Such effects can also be classified as content-related, including higher course grades,[13,44] improved content knowledge,[25] or perceived improvement in content knowledge,[26,27,38,44,51] as well as non-content-related, such as improved confidence[23,26−28,51] and development of leadership,[25,26,51] communication,[38] and teamwork skills.[26,27,38] Beyond content knowledge and intra- and interpersonal skills, there was a dearth of research on students' beliefs specifically about learning chemistry. Moreover, several of these studies examined subjects' self-perceived gains after their completion of the program through course/program evaluations or other open-ended surveys.[26−28,38,44,51] In this paper, data is collected to measure changes as they occur over time, in conjunction with reflective data, to further elucidate the direction and cause of change.

Learning Beliefs in Chemistry

As a whole, student beliefs about science have largely been correlated to their success and retention in the class and in STEM.[10,52,53] For example, beliefs about identity and belonging in a field have historically been linked to success and persistence in STEM, particularly for underrepresented students.[54−56] Moreover, beliefs about learning in STEM (metacognition, epistemology, the scientific process, relevance of science to the real world) are unsurprisingly different between novices and experts.[57−59] Such research characterizing the dichotomy between novice and expert learning has underscored the push for students to "think like a scientist" and develop skills needed for the modern world.[60]

Peer leaders serve as a liaison between faculty and the students they work with and are often high-performing students themselves, providing reasonable cause to place them at some midway point on the novice−expert spectrum. Concerning content skills such as problem-solving, the differences between novices and experts are evident: experts classify problems according to underlying principles ("deep structures"), whereas novices tend to use surface features.[61,62] Experts are better at focusing their attention on important details of a problem and are more likely to perform certain tasks automatically.[63−65] Further, studies have shown that those in-between novices and experts display some characteristics of both.[62,66] Beyond problem-solving, previous work has linked instructional methods and curriculum design to students' beliefs, attitudes, or epistemological development, also often in the context of expert versus novice thinking.[10,67−70] For example, Otero and Gray[68] found expert shifts using the CLASS in their physics and physical sciences courses for nonmajors, following a curriculum change that explicitly addressed the nature of science and science learning. In this study, investigating the affective transformations of peer leaders, who likely sit somewhere between experts and novices, means gaining better insight into the novice−expert shift and even pinpointing the experiences that shape scientific thinking. In the next section, we will describe the implementation of the Teaching Internship program in order to provide a thorough context for the present research study.

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THE TEACHING INTERNSHIP IN GENERAL CHEMISTRY

The General Chemistry Teaching Internship program was implemented in its current form in the Fall of 2015.[71] The internship is a for-credit course, as TIs are not paid a stipend and must register as they would for any other course. New TIs are invited to apply to the program each year on the basis of their performance in General Chemistry I and II. While they primarily earn top grades in the course, an "A" is not strictly required. Selection then follows small group interviews. Generally, TIs of previous years are permitted to return each year as they choose, and many do. The weekly course requirements are provided in Table 1 and include a staff meeting with the program coordinator (E.L.A.), multiple learning sessions with students (office hours, recitations, workshops, etc.), and semiguided written reflections that are accessible to all TIs. More details about the selection process and program components can be found in the Supporting Information.

Table 1. Certificate in Chemistry Education (CCE) Coursework and Requirements

Course	Length (Semesters)	Credits per Semester	Weekly Requirements
Introduction to Chemistry Education (Pedagogy Course)	1	3	Flipped class: 80 min One learning session: 1 h Written reflection
Teaching Internship	2+	1−2	Staff meeting: 1 h Multiple learning sessions: 2−4 h Written reflection
Teaching a Chemistry Lab	1+	3	Lab training: 3 h Teaching: 3 h

The Certificate in Chemistry Education (CCE)

For applicants who wish to become more involved in peer leadership, they are encouraged to apply for the Certificate in Chemistry Education (CCE) program (Table 1).[72] The required Pedagogy Course (PC) is a flipped-style 3-credit course created and taught by E.L.A. and includes both weekly teaching and classroom components. As these students work with General Chemistry students, they are also referred to as TIs, with the two groups differentiated as PC- and non-PC TIs. The course covers topics similar to the TI staff meetings; however, students in the PC source their knowledge from the assigned literature, delving deeper into the theories of education, and complete frequent assessments.

Following the PC, CCE participants enroll in the TI program, followed by leading their own section of the General Chemistry laboratories. In an effort to maintain inclusivity for students facing a semester of abnormally rigorous coursework, health challenges, or other unexpected circumstances, the CCE program can be flexible and nonlinear. For example, a small set of TIs applied to the TI program initially and later opted to take the PC.

FRAMEWORK: SITUATED LEARNING THROUGH TEACHING

The notion of teaching as a means for learning can be found throughout the education literature,[73−75] largely stemming from the pivotal work of Benware and Deci.[76] In their study, students performed better on an assessment when they believed they would teach the material, compared to those who believed they would be taking a traditional exam. Shook and Keup[7] write that peer leaders develop the abilities to combine and apply multiple skills to solve realistic, ill-structured, multifaceted problems, abilities often attributed to experts.[61,77−80] Given that student attitudes are tied to their problem-solving strategies[78,81] and performance in the class,[82,83] it is plausible that peer leaders also experience expert shifts in their beliefs about learning chemistry.

Situated Learning

Situated learning theory refutes the notion of knowledge as an entity to be gained by an isolated learner. Instead, it holds that knowledge gained is a result of some external interaction(s).[84] As a theoretical framework, situated learning addresses how learners interact with their environment, create meaning via social interactions, and achieve "old-timer" status in their community of practice (the TIs) via legitimate peripheral participation (teaching in their learning sessions).[85] As such, in an effort to study the TIs as a community of practice, it made sense to differentiate the experienced TIs (the "old-timers") from the newcomers in our analysis to understand the role that experience plays in shaping learning attitudes. Similarly, analysis should also consider the fact that the PC offers a different learning environment compared to the TI program alone. These decisions served as the prerequisite research questions (RQ1 and RQ2, below) needed to answer our primary question, RQ3. While surveys are not the traditional method associated with the situated learning framework, survey data was crucial in informing the qualitative approach used for RQ3. Such methods were then evaluated as RQ4 emerged during data analysis.

Research Questions

The research questions developed were as follows:

1. Do peer leaders' beliefs about learning chemistry correlate to their length in the program?
2. Do peer leaders' beliefs about learning chemistry correlate to whether or not they enroll in a formal Pedagogy Course?
3. Do peer leaders' beliefs about learning chemistry change over time as a result of their peer leadership experience?
4. Is the CLASS a valid means for assessing the beliefs of peer leaders?

METHODS

Setting

Rutgers is a large, R1 university and the state's only public land-granting university. This study was conducted on the main New Brunswick campus which hosts 36,000 undergraduate students and 14,000 graduate students.[86] Approximately 2,000 students enroll in General Chemistry each semester. Nearly three-quarters of these students are life science or pharmacy majors, followed by a minority of physical science and social science majors. Nursing and engineering students each have their own version of the course, which is

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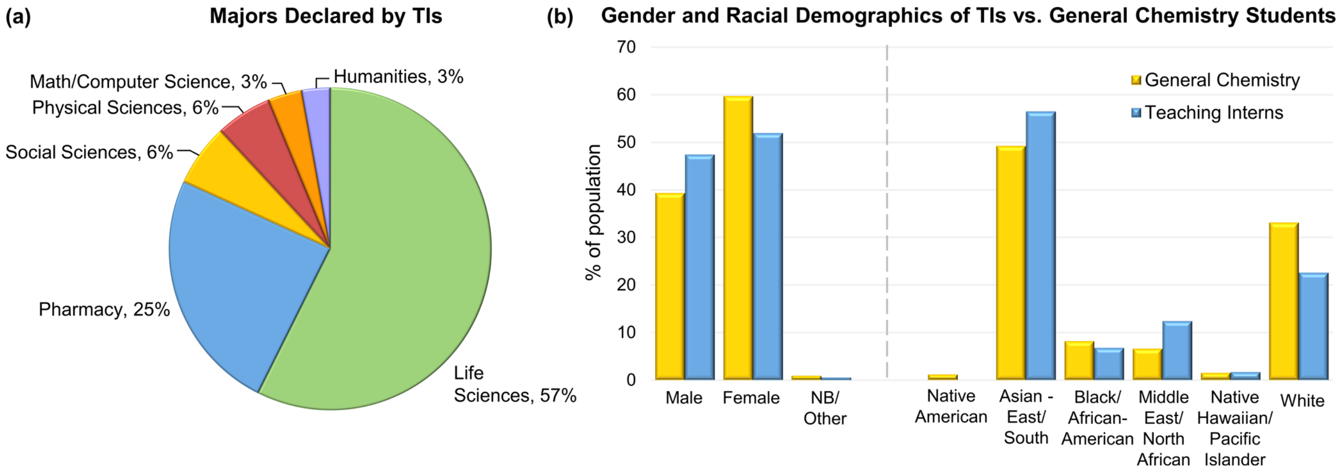

Figure 1. (a) Reported majors of all TIs from Fall 2015−Spring 2018 as a percentage (N = 179; 2 TIs reported double-majors). (b) The gender and racial makeup of General Chemistry students (Fall 2015; N = 1,510) and Teaching Interns (Fall 2015−Spring 2018; N = 177). Please note that the gender abbreviation "NB" refers to "nonbinary".

not served by the TIs. The General Chemistry courses include traditional lectures (∼300−400 students each), common-hour exams, and graded online homework.

Participants

TIs are selected from the General Chemistry course population which they will serve. Their declared majors are provided in Figure 1, along with demographic data that contrasts them with one cohort of General Chemistry students.

The Colorado Learning Attitudes about Science Survey (CLASS)

Beginning in the Fall of 2015, TIs were asked to complete the chemistry version of the CLASS.[87] The CLASS was originally designed for assessment in physics, but it was later adapted and validated for use in chemistry.[88] The CLASS-Chem provides 50 statements about chemistry and learning, and participants use a five-point Likert scale to note their level of agreement or disagreement. Instructors can then classify students' responses as evidence of "novice" or "expert" beliefs. Expert consensus has been established in previous work for 45 of these statements,[10,87] meaning experts (e.g., physics professors) converged on their level of agreement for these statements. Of these statements, 36 belong to one or more of the nine previously established categories to help provide meaning to the responses.[87] These categories are provided in Figure 2 and described in detail in the Supporting Information. Several of the CLASS items fall under multiple categories, and Figure 2 demonstrates the relative amount of overlap between categories; larger circles contain more items, and the larger the overlap is, the more items those categories share. Each category has a favorable and unfavorable section, which represent the percentage of statements by which students agreed or disagreed with the experts, respectively. Neutral responses are excluded from the scoring. Various measures are taken to flag responses that may not be genuine (see the Supporting Information, Section V).

The TIs complete the CLASS as a pretest and post-test in the beginning of the fall semester and at the end of the spring semester, respectively. Thus, students who have been TIs for multiple years have completed the survey more than twice. TIs who only remained in the program for one semester did not complete a post-test and are excluded from the results. TIs enrolled in the PC, offered only in the fall, are also given a post-test at the end of the fall semester. Data was collected for three academic years, as shown in Table 2.

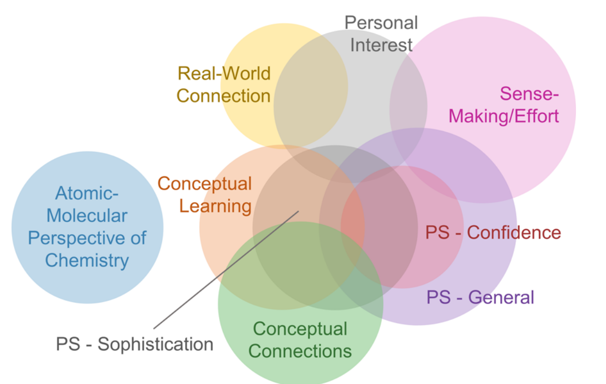

Figure 2. A Venn diagram displays all nine categories of the CLASS. "PS" is shortened for "problem-solving". The size of the circle corresponds to the number of items in that category; the size of the overlap refers to the number of items that sit in two or more categories. The PS-sophistication and PS-confidence categories have only items that also live in other categories, while the atomic-molecular perspective of chemistry items exist entirely in their own category.

Table 2. TI Enrollment by Academic Year

Academic Year	TI Status	Fall, PC	Fall, TI Only	Spring, TI Only
2015−2016	New	11	27	34
	Returning	6	7	4
2016−2017	New	12	20	25
	Returning	1	20	11
2017−2018	New	13	20	24
	Returning	2	22	14

A myriad of instruments have been developed for measuring chemistry students' attitudes, beliefs, expectations, self-concept, epistemologies, and so on.[87,89−94] While there are important differences between these constructs, such analysis is beyond the scope of this paper and has been discussed previously.[89,95,96] The decision to implement the CLASS over other assessment tools came down to practicality and applicability. The CLASS did not refer to a specific course

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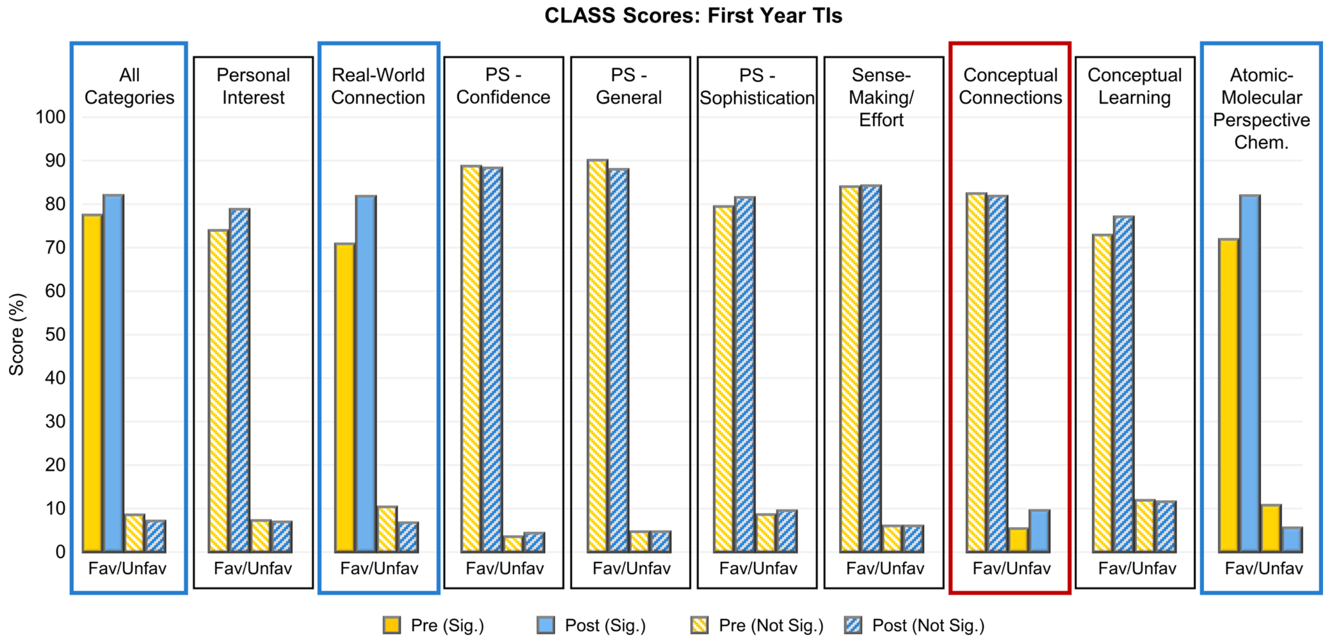

Figure 3. Matched CLASS pretest and post-test results for all first-year TIs. Pretests were administered in the Fall semesters, prior to the first week of the program. Post-tests were administered in the Spring semesters during the final week of the program. Blue outlines denote large ($p \leq 0.05$) expert shifts, while red outlines denote novice shifts ($p \leq 0.05$). Biserial-rank correlations are provided as effect size ($N = 48$).

or course component, such as a lab, which would have been inappropriate for our sample. Likewise, a homogeneously high-performing population may have negated the usefulness of a self-concept measurement.[97]

While overlapping categories within the instrument have brought the discriminant validity of the CLASS into question,[98] the categories themselves were of secondary importance. The CLASS items best aligned with the intended research questions, and the plan to conduct further investigation beyond the survey would provide additional meaning behind the quantitative results.

Nonparametric statistical tests were performed in SPSS to analyze survey data, after a Shapiro–Wilk test showed that the results were not normally distributed. Specifically, the Wilcoxon signed-rank test was used to identify large shifts in TIs' matched pretest and post-test scores. Due to sample size concerns, the test was performed using exact calculations (as opposed to asymptotic). Effect sizes are reported as rank-biserial correlations, r.[99] A detailed description of these calculations can be found in the Supporting Information.

Interviews

Because the CLASS had never been used on this population, we felt that conducting interviews would provide insight as to how these participants were interacting with the instrument. A stratified sample of 13 TIs was selected to participate in an interview. TIs were sorted by gender, PC enrollment (or lack thereof), and year in the TI program. TIs were then randomly selected from these categories where possible.

The interviewee's collective CLASS responses were used as a rough interview guide. To prepare for each individual interview, the interviewer (E.L.A.) noted items that had large shifts, novice responses, or responses that differed from the majority of the other TIs. The interviewer asked TIs to recall their responses and consider their reasoning, particularly stating what context they were thinking about when they selected their answer. Interviewees were given a physical copy of the CLASS instrument but not their responses. To minimize bias, the interviewer did not make any references to the TI/CCE programs until the final question, unless it was first prompted by a TI. Audio data was collected, transcribed, and coded using NVivo version 11.

IRB Approval

All methods and procedures were granted IRB approval from the university, under IRB protocol 15-813M, with annual renewal.

RESULTS

RQ1: CLASS by Year in Program

To measure the attitudinal changes that take place over time in the program, it seemed logical to look at the TIs' scores based on their number of years in the program. Matched data from all first- and second-year TIs were separated. While some TIs had completed three years in the program, the sample size was too small ($N = 7$) to obtain meaningful results. Data collected during a TI's enrollment in the Pedagogy Course were excluded. To check for possible inconsistencies between academic years, a Kruskal–Wallis test was run to compare scores between the three academic years for both groups. No significant differences were found, supporting the decision to combine all first-year TIs into one group and second-year TIs into a second group.

Figure 3 shows a large, expert shift in the "All Categories" section for first-year TIs. Large shifts also appeared in three of the categories: Real World Connection, Atomic-Molecular Perspective of Chemistry, and Conceptual Connections. The first two categories saw shifts in the expert direction, with the Atomic-Molecular Perspective of Chemistry category demonstrating both a significant gain in the favorable responses (F) and loss in the unfavorable responses (U). However, the Conceptual Connections category saw a novice shift due to the rise of the unfavorable score. Effect sizes were calculated using a rank-biserial correlation, r. Figure 3 illustrates these changes and provides the effect sizes. Exact scores and shifts can be found in Table S1 in the Supporting Information.

Second-year TIs (Table S2) also demonstrated desirable shifts in the combined "All Categories" (r = 0.78) and in the Atomic-Molecular Perspective of Chemistry category (r = 0.67). The full table of scores can be found in the Supporting Information (Tables S1 and S2). Notably, the large undesirable shift in the Conceptual Connections category was not seen in the second-year, with the second-year's post-test score being greater than the first-year's pretest score. While sample sizes precluded direct comparisons between the groups, the results were encouraging and informative for qualitative purposes.

RQ2: CLASS by Pedagogy Course Enrollment

To understand the role of the Pedagogy Course, PC TIs were analyzed separately. TIs opting to take the PC were given a separate pretest and post-test at the beginning and end of the one-semester course. These TIs saw approximately 50% less facetime with students and worked primarily in traditional office hours, rather than in structured learning sessions like recitations and workshops. In a similar fashion to RQ1, a Kruskal–Wallis test was used to check the assumption that there were no differences between academic years. Again, this assumption was supported, and all PC TIs were combined into one group. This group showed a large novice shift in Personal Interest ($N = 42$, $p \leq 0.05$, $r = -1$) and no large expert shifts. We considered that those who enroll in the PC may begin the program with different attitudes compared to those who enroll only in the TI program. However, we did not see any notable differences between pretest scores of PC and non-PC TIs for any category. All scores for this group can be found in Figure S3.

RQ3, Part I: Relationship of Coursework and CLASS Responses

The third and primary research question asks how the experiences gained by a peer leader are tied to their beliefs about learning and was motivated by discrepancies in the CLASS responses. While a majority of large shifts were in the expert direction, when looking at the individual item responses, there were some statements that had a large novice consensus. Because the CLASS does not make specific mention of a particular chemistry course, we questioned whether other coursework could be a confounding factor in TIs' responses. Previous studies have shown differences in scores between General and Organic Chemistry students, which the majority of TIs had taken or were enrolled in at the time.[87] Likewise, we sought to better understand the TIs' responses to the CLASS, as this instrument had not been previously reported on for peer leaders. For these reasons, it was necessary to determine what coursework or experiences motivated TIs' responses to the CLASS.

As previously described, the participants' (Table 3) CLASS responses were used to guide the interview protocol. Of the 50 CLASS items, 30 were discussed at least once between the 13 interviews, with some items appearing in as many as 10 interviews. In total, there were 79 instances in which the interviewer asked about a specific CLASS item. In 62 of those 79 instances, the TI was able to recall the context that they were considering when responding to that item. Each context response was coded according to course identity or fell under the category of "Chemistry/Science as a Whole". As some TIs discussed more than one context per item, the total "Number of Mentions" is greater than 79. The results are shown in Table 4.

Table 3. Interviewee Profiles

Pedagogy Course	Gender	1st Year[a]	2nd/3rd Year[a]
Completed	Female	Zara	Marla
		Manasi	
	Male	Niven	
		Raj	
Did not enroll	Female	Nanjana	Reema
		Emma	
	Male	Sami	Kenny
		George	Darsh
		Ronit	

[a]Names have been changed.

Table 4. Context of CLASS Items

Context	Number of Mentions	Number of TIs[a]	Percent of All Mentions
Organic Chemistry	34	12	36.6%
TI Program/Pedagogy Course	25	11	26.9%
General Chemistry	23	13	24.7%
Other Science Course	5	4	5.4%
Chemistry/Science as a Whole	4	3	4.3%
Nonscience Course	2	1	2.1%

[a]The number of TIs (out of 13) that referenced that context.

Organic Chemistry was identified the most when prompted with a specific CLASS item, followed by the Teaching Internship/Pedagogy Course and General Chemistry. Only General Chemistry was mentioned by all 13 TIs interviewed, although the first two followed closely behind.

All 13 TIs cited more than one context during their interview, and some even stated multiple contexts for a single item, noting that it changed over time based on their coursework. This supported our original hypothesis that the increased coursework experience could be a confounding factor. One third-year TI, Reema, exemplified how strongly her concurrent coursework influenced her answers. Like most TIs, Reema was enrolled in Organic Chemistry during her first year as a TI. During this time, her response to item 37 (Box 1) had a novice shift. However, the following year, her responses indicated that an expert shift had occurred. A snippet of her response can be found in Box 1.

In fact, of the 10 interviews in which item 37 was discussed, nine of the TIs' responses cited Organic Chemistry as the reason for their response. Notably, this item is a part of the Conceptual Connections category on the CLASS, which was the only category that saw a novice shift among the first-year TIs.

RQ3, Part II: Origin of Attitudinal Shifts

With strong evidence that individual TIs implicated different contexts while completing the CLASS, it was pertinent to understand the root of the various shifts. To separate the survey data accordingly, the contexts were first mapped to the categories each time a specific CLASS item appeared in the interviews (Figure 4). Please note that items from the category "Real World Connections" were not associated with any context during any of the interviews and are thus excluded

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Box 1. Snippet of Interview with Reema

CLASS Item 37: "In learning chemistry, I usually memorize reactions rather than make sense of the underlying physical concepts."

Interviewer: *When you first came into the [TI] program you disagreed with [Item 37]... that you do NOT usually memorize these reactions instead of making sense, but then you went to agree after one year... when you were still a sophomore.*

Reema: *Yeah*

Interviewer: *When you see this question, what are you thinking of? What were you answering that in the context—*

Reema: [interrupts] *As a sophomore? Orgo!* Where you memorize like a sheet of 50 reactions without thinking about it? Yeah.*

Interviewer: *Okay—*

Reema: *Like when you are in [General Chemistry], you are not working with the same kinds of reactions again and again so you have to understand which one's an acid, which one's a base and then go from there.*

Me: *Right.*

Reema: *Versus Orgo, you do that, but there was so much that at a certain point you just did not have time to.*

Me: *I understand. And after that year, you consistently selected strongly disagree.*

Reema: [laughs] *Yeah. Once I was done being in Orgo.*

*"Orgo" is the common term for the Organic Chemistry sequence.

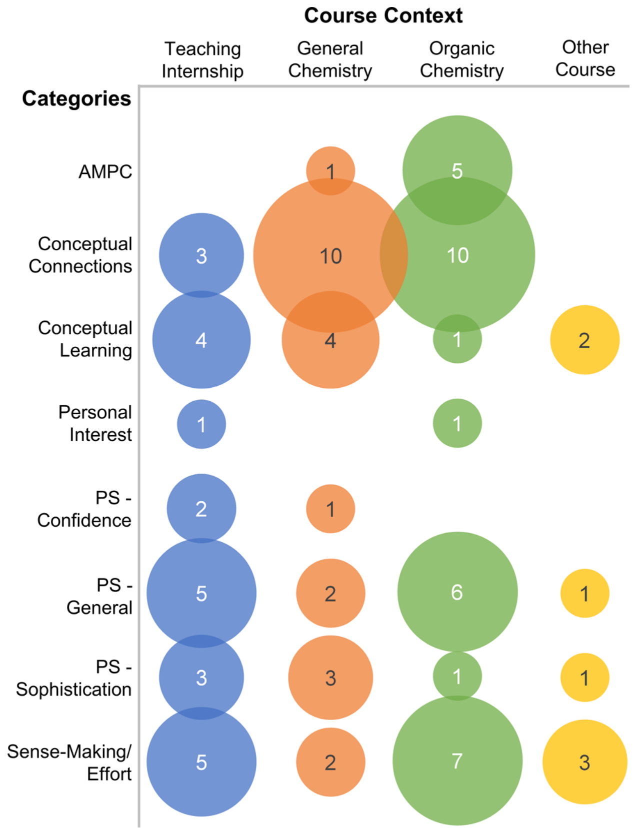

Figure 4. This data is based on responses from the interviews with TIs, in which TIs were asked to provide the context that informed their responses on specific CLASS items. CLASS categories are listed on the left, while the courses appear across the top. The bubbles represent the instances in which a CLASS item, belonging to one or more categories, was associated with a specific course. The number of instances is written in the middle of each bubble, and the size of the bubble is commensurate with this number. If an item belonged to two or more categories, it was included as such. Please note that "PS" is abbreviated for "Problem-Solving" and "AMPC" is abbreviated for "Atomic-Molecular Perspective of Chemistry". An alternative representation of this data may be found in the Supporting Information (Figure S1).

from the map. Additionally, a small number of items that were discussed during the interviews do not belong to a CLASS category, accounting for slight discrepancies between the totals in Figure 4 and those provided in Table 4.

The next step was to map the general direction of the shifts to each course context. As this could only be done for instances in which an interviewee explicitly related a specific context to a shift that they could recall, gathering a large data set was challenging. To maintain consistency with the previous methods, the Agree and Strongly Agree options were grouped as "Agree" and Strongly Disagree and Disagree were grouped as "Disagree". Shifts were then only defined as any change between Agree, Neither Agree/Disagree, and Disagree. Thus, shifts from "Agree" to "Strongly Agree," for example, were not counted. In total, 42 instances were identified in which an interviewee explicitly linked a specific context to a shift in their CLASS responses. General Chemistry was not identified as a cause, which was fitting because none of the TIs were enrolled in General Chemistry during their time in the TI program.

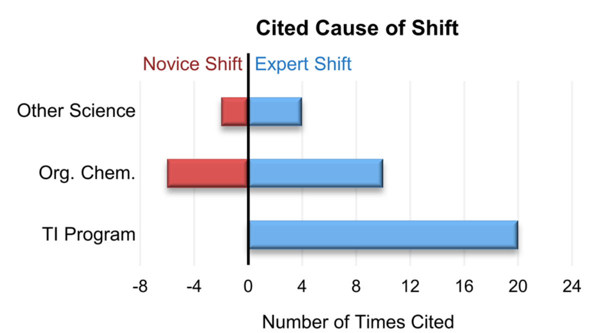

Figure 5. Interviewees recalled the cause of any shifts from their CLASS results. The main causes were classified as the TI Program, Organic Chemistry (Org. Chem.), or another science course. General Chemistry and nonscience courses were not identified by any of the TIs as a cause of a shift. Red indicates a novice shift, while blue indicates an expert shift.

As shown in Figure 5, a majority of shifts were in the expert direction for all three contexts. However, in all instances in which the TI program was cited as the cause, the shifts were favorable. To probe further, the interviewer concluded each interview by asking TIs to consider ways that the TI program may have affected their general attitudes toward learning or chemistry. All 13 interviewees stated various experiences of positive personal growth resulting directly from the TI/CCE programs, including improved metacognition, confidence, study skills, time management, and resilience. These benefits are elaborated on in the following section.

RQ3, Part III: Other Benefits to Being a Peer Leader

Throughout the interviews, TIs made numerous references to the ways that being a peer leader shaped their beliefs about learning, science, or even about themselves, outside the context of the CLASS. A total of 71 such instances were extracted from these interviews, from all 13 interviewees. These excerpts were

Table 5. Other TI Benefits

Category	Number of Mentions	Percent of Mentions	Interview Excerpt
			Improved Skills or Knowledge
Pedagogical Knowledge and Techniques	20	28.2	*My first semester teaching, I'd look at my notes and memorize and be like a robot communicating to the students. But this semester, I do not want to tell them word-for-word a definition. I want to get them to explain it in their own words. Then they're not memorizing things. They're trying to make sense of chemistry.* (Sami)
Problem-Solving Strategies	12	16.9	*Honestly I've learned a lot of different methods, not by myself actually, but by a lot of the students. They'll be like "oh I learned this in high school," and I just go with it with them... and it helps that way, because now I get a different view of the problem* (George)
Learning Through Teaching	7	9.9	*Just growing from the TI program itself, I've learned to apply some of the ideas about learning in my other courses* (Nanjana)
Content Knowledge	4	5.6	*When you discuss [chemistry] with students and you are trying to explain it to them, I realized my own knowledge of chemistry had become so much better* (George)
			View of Chemistry
Conceptual Connections	8	11.3	*When I was in chemistry, I did not think all these concepts were connected. But teaching it, and not being in the class but still knowing the answers to questions made me realize, now I got the underlying concepts down. And I do not think a class taught me that. I think the internship taught me that.* (Reema)
Personal Interest/ Enjoy Chemistry	4	5.6	[on preparing for teaching] *It is a more rewarding experience, instead of prepping for a class. It is more, "how can I lead them through the process?" And I really enjoy that.* (Kenny)
Chemistry in the Real World	3	4.2	*By being a TI I would say that I've realized chemistry is everywhere in life. You do not think about it all the time, but then you'll see something and you'll be like "oh I know how that happens!"* (Manasi)
			Interpersonal/Intrapersonal Growth
Confidence/ Persistence	4	5.6	*I think that [TI-ing] made me more confident in what I think I know about Gen Chem, or chemistry in general.* (Marla)
Empathy/ Appreciation	9	12.7	*I work in a hospital and I'm better on the patient care aspect now. Like when explaining their medication or their schedule for the day. I'm more, I guess, empathetic. That reminds me of how I used to teach people versus now.* (Emma)

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coded by the first researcher (E.L.A.), using an open-coding scheme. The second researcher (D.M.Y.) independently coded 38/71 of these excerpts using the coding scheme provided, with the option to make changes to the coding scheme if necessary. Eleven categories were developed from these codes, but they were collapsed into nine categories upon discussion with the second researcher. Agreement was initially reached on 35 of the 38 excerpts (92.1%), and upon further discussion, the researchers resolved all discrepancies. Results of this analysis can be found in Table 5, and definitions of each category can be found in Table S4 of the Supporting Information.

The most common finding to emerge fell under "Improved Skills and Knowledge", specifically that TIs' Pedagogical Knowledge and Techniques had improved dramatically. While both the TI and CCE programs include a training component, the fact that improved pedagogical content knowledge was a notable benefit that the TIs discussed unprompted was surprising. Further, most TIs (9/13) stated a marked improvement in their problem-solving strategies and/or content knowledge, which is consistent with previous studies on similar populations.[25,26,44,51]

Stepping away from the chemistry, another often-discussed benefit was labeled Empathy/Appreciation, whereby TIs acknowledged developing a better understanding of students' struggles or a newfound appreciation of their own professors. Indeed, at the end of the interview, when asked how the TI program changed their views of chemistry, one TI described how their students gave them a new understanding of their own past experiences:

> *"Where I went to school, originally, that area is kind of an underserved area. And then moving, having the majority of my high school in [a wealthier town], that really changed me. But even then, when I thought about chemistry, I overlooked that, because for me, it was generally like if you work for it, you get it. But it's not necessarily like that because if some people are coming from an area where they haven't been paid attention to their entire life, there's just some things you can't change, so I feel like I'm noticing things like that more now." (Nanjana)*

When the topic of empathy arose, four TIs referenced the lesson on equity, inclusion, and diversity from their weekly staff meetings, suggesting that these topics left a lasting impact.

RQ4: CLASS Utility for Peer Leaders

The final research question asks whether or not the CLASS is a suitable, valid instrument for assessing the learning beliefs of peer leaders. There were instances in which a TI would contradict their written answers in an interview or state that they did not know why they answered the way they did. When this occurred, the item and response were discarded from the aforementioned qualitative analysis. The most commonly stated cause for these discrepancies was a misunderstanding of the question. Nine of the 13 TIs cited this at least once during their interview, with none of them stating it more than twice. On the other hand, it is possible that meanings changed over time:

> *"Initially I agreed [that doing lots of problems was helpful], but actually, from my perspective now, I didn't realize how many problems other people did. I genuinely had no idea. I did maybe two practice exams max and I thought that was a lot. Until I started working with students." (Ronit)*

Other potential sources for a discrepancy could be survey fatigue (taking the CLASS multiple times over the years) or simple forgetfulness. The "lazy data" removed from statistical analysis was not included in the interviews.

Ultimately, mixed results on the survey indicated that the survey data alone was not satisfactory to determine the effect that the TI program had on these participants' attitudes. Interview data suggested that TIs were implicating multiple different contexts when responding to the survey items, and that different contexts were associated with different attitudes:

> *"I think I did most of [the survey] in the mindset of Gen Chem. But the questions about how you feel about the subject of chemistry, I was thinking of being a TI. So it depends on the question. But I wouldn't say as an Orgo student. My thoughts on Orgo are a little different." (Niven)*

Interestingly, five TIs explicitly acknowledged approaching their own current coursework differently from how they encourage their students to approach it. For example:

> *"When the student comes in, I have to encourage them, even though it's not what I necessarily always do, I tell them you can't just sit there and memorize this, that you have to understand why it works. I try to explain that, even though I don't always do that myself." (Zara)*

> *"The biggest thing was that it's important for them to do the process rather than just give them answers, to have them work through it... but then sometimes I go to office hours and I might just really want the answer [laughing]." (Kenny)*

This lends support to the idea that, for this particular population that has experienced multiple chemistry courses, the CLASS is not simply assessing "chemistry" as a particular course, but perhaps a combination of courses or prior experiences, or even as a discipline in general, as one TI stated "I was just thinking of my experiences in general, like with my entire chemistry career." (Emma)

■ DISCUSSION: CONTEXT MATTERS

From the data presented here, it appears that TIs do experience positive growth in their attitudes toward learning chemistry as a result of their time in the program. This is consistent with previous work that has shown that different instructional practices can impact students' scientific beliefs.[68,70,100] All TIs participated in some form of weekly pedagogy training that focused on the nature of learning and the scientific process and received continuous feedback on how to apply their training to actual teaching experiences. Likewise, these findings add to the growing body of knowledge about the benefits that peer leaders have been shown to gain.[13,23,25−28,38,44,51]

TIs who opt to take the Pedagogy Course were not found to have large changes in learning attitudes during their first semester. Further, there was no evidence to suggest that these PC and non-PC TIs begin their respective programs with different attitudes. It is possible that one semester, approximately 14 weeks, is not enough time to capture meaningful data, keeping in mind that the PC TIs only gained half the teaching experience as the non-PC TIs. Alternatively, it could be that the PC TIs' training was simply different in nature, the results of which could not be properly evaluated by the CLASS. Previous studies have shown that a formal pedagogy course did offer unique benefits, suggesting that this latter possibility may hold some truth.[25,28,101,102] For example, in their study on a population that included TIs, Blackwell et al. identify the PC as "the most critical component of [peer leaders'] training and professional development", citing one peer leader who stated that the course was influential in learning about their own learning.[25] Further, our own course evaluations of the PC have been overwhelmingly positive. Perhaps most encouragingly, the small number of TIs who took the PC after one or more semesters of being a TI noted benefits gained specifically due to the PC. More rigorous work on a larger sample would be needed to fully capture any differences between PC and non-PC TIs.

Concerning our primary research question, RQ3, interview data ultimately aided in our understanding of how the TI program, through teaching or training, affects TIs' attitudes toward learning chemistry. Each mention of peer leadership corresponded to expert responses and/or shifts in attitudes. Aside from specific items from the survey, TI responses about their experience in the program suggested that they gained valuable skills and a matured perspective on their own education and on chemistry and learning in general.

All 13 interviewees stated that their responses were context-dependent. Interestingly, one interviewee stated that when they were conflicted about their level of agreement for an item because they were considering two different contexts, their beliefs developed from the TI program took higher precedence and affected their survey response accordingly. While it is not possible to generalize this statement to the population, there were multiple instances in which TIs admitted to not always practicing what they preached. This sentiment was similar to that found by Adams et al.,[103] in which physics students taking the CLASS were found to hold personal beliefs that differed from beliefs they perceived an expert would hold.

■ CHALLENGES AND LIMITATIONS

One challenge for conducting this study was that participants were asked to discuss coursework and the CCE/TI programs with the programs' coordinator. This introduces the possibility that certain beliefs or experiences were not disclosed by the TIs if they felt that those beliefs and experiences were not positive or aligned with the programs' pedagogical philosophy. To minimize these concerns, interviews were conducted at the end of the Spring 2018 semester, after TIs were presumably more at ease in the program. Continuous efforts were made throughout the year to invite constructive feedback from TIs, encourage honest self-reflection, and promote a safe environment for discussion. For the interview, participants were told that the purpose was to understand their coursework experiences in general. At no point during the CLASS portion of the interview did the interviewer explicitly name the TI program unless it was brought up by the interviewee, so as to avoid any "prompting". The final question asking them to discuss their experiences and attitudes as a TI was purposefully reserved for the end.

One limitation for this study is the modest sample size. Typically, the CLASS has been administered in large courses, such as General Physics or General Chemistry, where the sample size can extend into the thousands. In this case, the sample size reduced the statistical power and impeded the ability to draw many meaningful conclusions from the quantitative data alone. Second, this sample was relatively homogeneous in terms of academics. The TIs were selected from the top of their General Chemistry class and enrolled in similar coursework, and the overwhelming majority held interest in healthcare careers. Even in cases of novice shifts, their CLASS scores were still high compared to a typical General Chemistry population,[87] introducing the possibility of "maxing out" the instrument. Still, the qualitative data provided meaning to some of the results where the statistics could not.

■ IMPLICATIONS FOR INSTRUCTION AND RESEARCH

The calls to promote classroom equity and to foster so-called "21st Century Skills" such as scientific thinking have shaped recent educational practices.[9,104−109] The paradigm of learning through teaching is well-supported, and this research suggests that teaching, and learning how to teach, may impact one's beliefs about learning science, and thus their scientific thinking. Encouraging this as a practice either through formal programs like the Teaching Internship or simply as a classroom exercise may foster this type of development in our STEM students.

Interview evidence suggested that at least some TIs simultaneously hold opposing expert and novice beliefs about learning and that they may act on those beliefs differently given a specific context. If we suppose that a TI's conflicting beliefs are a direct result of their diverse experiences, it would be of interest to examine what factors of a course or program determine precedence in their selection. For practitioners, this fact also emphasizes the importance of incorporating practices that foster positive/expert beliefs about science and learning throughout multiple courses, rather than isolating these practices as their own entity.

Within our own population, these findings have prompted modifications to the PC and TI staff meetings. For example, TIs are given in-class activities which provide opportunities for them to explicitly apply their pedagogical knowledge to their own coursework, such as Organic Chemistry, in addition to their General Chemistry duties. By encouraging a broader application of these skills and concepts, TIs may not only improve their General Chemistry pedagogical content knowledge but perhaps also develop more expert-like attitudes about learning and chemistry across the field. In a similar manner, small changes have since been made to discuss the importance of empathy when working with students. Topics of equity, inclusion, and diversity have been incorporated within other topics throughout the semester for both the PC and the TI staff meetings.

To our knowledge, detailed CLASS data has not been reported on previously for a peer leader population, although Otero et al. do note positive overall attitude changes in Physics LAs.[110] The instrument served as a valuable starting point for our investigation on peer instructors' learning attitudes about chemistry. Interviews were then necessary as a means of clarification for conflicting or unexpected responses, as well as to assess the validity of its use in our population. In the future, a modified version of the survey may help to more easily pinpoint attitude changes specific to a peer leader's role. Such an instrument could investigate similar beliefs about learning chemistry, while prompting participants to consider their training or experiences in this role. This data may inform the pedagogical practices and/or overall structure of the program to target peer leaders' learning beliefs. Alternatively, this data could be compared with their attitudes stemming from other coursework, expanding upon the work discussed in this paper. If similar results are found, such that peer leaders do compartmentalize or rank beliefs based on a specific context, it may be worth investigating why this divergence occurs and providing an argument for incorporating explicit pedagogical content knowledge within the early general STEM course curricula.

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ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available at https://pubs.acs.org/doi/10.1021/acs.jchemed.0c00129.

Further description of the Teaching Internship Program, further description of the Certificate in Chemistry Education Program, details on the statistical methods chosen, and supplemental data tables (PDF, DOCX)

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Notes

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