The Impact of Continuous Instructional Development on Graduate and Undergraduate Students

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Graduate instructors are often the chief and central human resource for students. They play a major role in bringing about the desired department and faculty goals in introductory chemistry courses where class sizes of 400–600 students are not unusual. The importance of graduate instructors in undergraduate instruction is reflected in the large number of citations (400+) obtained from an ERIC (*1*) search. Most of these articles, published in the late 1980s and early 1990s, describe numerous approaches that were designed to address graduate instructors' needs in various disciplines and courses.

The role of graduate instructor is unique in that it entails working on both sides of the desk—as a student in graduate courses and as an instructor for financial support. Many graduate instructors come to graduate research programs with either limited or no previous teaching experience, and therefore, often without the knowledge of how and what to prepare for their instructional assignments. Their attention and interest are focused on future research plans and they have little or no pedagogical or experiential background to draw upon to help them bridge the common academic gaps their students bring to a general chemistry course. Without this background, most "teach as they have been taught" or assume that their "expertise" will get them through a class. These strategies ultimately lead to a frustrating experience for both students and graduate instructors.

A number of colleges and universities provide some teacher training as part of their graduate student orientation program or as a multiday "teacher training boot camp" in order to rectify this situation and improve the quality of teaching at the undergraduate level. Although both approaches are well received initially by graduate instructors, they are by time and nature limited in scope. Under some circumstances, some graduate instructors do not have the skills or experience to maintain a high degree of student participation and may resort to being an "answer book". Some lose control of the class because of communication difficulties and culturally based differences in teaching attitudes and styles. The graduate instructors at Purdue are no exception, and for this reason we chose to help graduate instructors deal with classroom issues when the issues arose.

Our short-term goal was to help graduate instructors in the general chemistry course for science and engineering majors establish an environment of positive and active interaction between themselves and their students in the recitation sections of large lecture courses. We hoped the plan would add value to the department orientation program by assisting and encouraging graduate instructors to learn to teach in interactive ways throughout the semester within an existing course structure but would not require much additional demand on graduate student time. Given that Purdue, like most universities, conducts a teacher-training program during the new graduate student orientation, we wanted to know if and how training on a regular basis throughout a course, with faculty and staff feedback, would be received by graduate instructors and what impact this kind of training would have on their teaching effectiveness. We were interested in pursuing answers to the following questions:

1. Would graduate instructors "buy in" and actually use interactive techniques in their recitations and, if they did, would they continue with this interactive teaching throughout the entire semester and possibly in future classes?
2. Would students cooperate with graduate instructors and each other and participate in active modes of learning?
3. Would the interactive teaching in recitations affect student behavior or attitudes toward the course or the graduate instructor?

The long-term goal is to move the learning environment to one where students take more responsibility for their learning and graduate instructors move away from the role of information giver or "expert" and assume a role as coach or facilitator for student learning.

Methodology

University and Department Orientation for Incoming Graduate Students

All incoming chemistry graduate students at Purdue participate in the university and department four-day orientation program during the week before fall-semester classes begin. This orientation includes an introduction to the university and the department and presentations regarding diversity issues, professional ethics, and chemical safety. One and one-half days of teaching-related activities include laboratory activities that graduate instructors complete in cooperative groups, videotaped micro teaching sessions of each graduate student that are evaluated for classroom technical presentation skills, and discussions about classroom management, grading, and record keeping. Interactive seminars focusing on learning theories and teaching techniques (*2*) are conducted.

While this orientation has been evaluated as very helpful to graduate instructors, we were interested in approaches to help graduate instructors with teaching techniques after they had some personal experience in the classroom and were at a heightened state of "readiness to learn".

The Nature of the General Chemistry Course, Students and Graduate Instructors

The weekly course schedule involves two 50-minute lectures, one 50-minute recitation, and one 3-hour lab. Five lecture divisions comprised the entire course. The instructional and support staff for the course included four faculty, 46 graduate instructors, one course supervisor, two assistant supervisors, and one laboratory prep chemist. The majority of graduate instructors were assigned to teach two sections

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(1 section = 1 recitation + 1 lab) and were required to have one office hour per week. Graduate instructors' assignments were constrained by their course schedules, but the assignments to course divisions were random within the pool of graduate instructors who could be assigned to the course. The majority of students in the course were in freshman engineering (60%), science (15%), health sciences (10%), and agriculture (6%). The SAT Math average of students in this course was 579.

Three lecture divisions were designated as the trial group; two were the control (comparison) group. General information about each group is summarized in Table 1. The final course grades were based on an absolute scale that was predetermined and announced at the beginning of the semester.

The Development Plan for the Trial Group

The decision to focus on recitation activities evolved from feedback from students and graduate instructors during previous semesters about what was happening during this scheduled class time. Believing that recitations should benefit all students—not just vocal ones or those who want the graduate instructor to solve their homework problems—we felt that this component of the course needed to become more interactive. Consequently, to acquire a workable comfort level with interactive techniques, the majority of graduate instructors would need practice and assistance in learning to move away from the chalkboard. Other classroom management issues, such as time management and discipline, would also need attention to help graduate students implement an interactive teaching style.

Table 1. Information about Classes

Characteristic	Instructor Group	
	Trial	Control
Number of students		
beginning of semester	1239	846
end of semester	1139	771
Number of students per section (max)	24	24
Number of graduate instructors	27	19
women	5	5
men	22	14
Instructors' teaching experience at Purdue, years		
0	13	11
1	6	3
2+	8	5

Table 2. Schedule for Trial-Group Recitations

Time Period	Activity
5–10 minutes	Announcements, etc.
25–30 minutes	Active learning by students in small groups: (1) students solve problems prepared by graduate instructor; selected student(s) from each group write their work on the board, present and explain it to the class; or (2) "homework check" in groups, or (3) some combination of the above
15 minutes	Quizzes (written by faculty) completed individually by students

On the basis of research showing that there is a connection between teacher behavior and student achievement (*3*), we adopted the "teacher as facilitator" model (*4*) to describe effective teaching- and structure-development activities. The development activities modeled several critical factors that graduate instructors would be asked to plan and incorporate into their recitations. Graduate instructors would (i) model procedures and provide examples that clearly convey the concepts taught, (ii) provide students with guided practice using the new material, (iii) provide effective feedback to students, and (iv) give students the opportunity to develop proficiency and fluency by engaging in independent practice or application of the concepts and new material.

A strategy that approached teaching issues and teacher development from several directions was designed to minimize the extra time graduate instructors would need to invest in this development and yet be able to deal with issues and experiences in a timely manner. Graduate instructors in the trial group were required to teach in ways that actively involve students in their (the students') learning, prepare learning materials for recitation, and attend the twice-weekly faculty lectures.

The required weekly team meeting was chosen to be the main conduit for discussion and communication among faculty, graduate instructors, and staff. Meetings for the trial instructional team throughout the semester were interactive and every effort was made to establish and facilitate an open, collegial environment. Time was designated for discussion and sharing of classroom experiences, asking questions, making suggestions, etc. throughout the semester. Three "micro-workshops", about 20–30 minutes each, were conducted during trial group team meetings (weeks 5, 7, and 9). The activities in the "micro-workshops" (role-playing, pre-recitation preparation, and connecting concepts) were designed to enhance graduate instructors' understanding of various aspects of effective teaching and to provide practice and activities that would facilitate an increase in both knowledge of and comfort levels with interactive teaching strategies. Graduate instructors in the trial group were required to prepare two or three questions or problems similar to homework problems and have them approved by the faculty before being used in the recitations. Graduate instructors signed an attendance sheet at the lectures they attended.

New techniques require different time and classroom management skills, so the graduate instructors were given a time schedule to follow in recitations (see Table 2) as they implemented interactive teaching strategies required by the faculty. Working groups of students in recitation were informal and membership could change from week to week. Four members per group was the recommended maximum size. Graduate instructors were encouraged to distribute any graded lab reports during the lab periods in order to reduce distractions during recitations.

Shortly after the micro-workshops began, faculty in the trial group visited at least one recitation conducted by each graduate instructor assigned to their divisions and provided feedback to the graduate instructor.

The staff of the control group met weekly with the purpose of informing graduate instructors of laboratory procedures and safety, as well as deadlines and other important details for the week. This had been the standard staff-meeting format in general chemistry at Purdue for many years. The

graduate instructors in the control group received no additional information about teaching techniques beyond what was provided in the fall department orientation, and they could conduct their recitations in a manner of their choosing. They were told that preparing for recitations and attending lectures were part of the department's expectations associated with the duties of their teaching assignment, but, consistent with previous department practice, no attempts were made to document recitation preparation or lecture attendance.

Evaluation

At the end of the semester, graduate instructors in trial and control groups completed questionnaires using a Likert scale of 1 (strongly disagree) to 7 (strongly agree). The trial and control group questionnaires had 22 common statements. The trial group questionnaire had three additional statements that sought to evaluate various activities that had comprised the development program.

Students responded to the standard 20-item end-of-semester department graduate instructor evaluation plus an additional nine questions using a 1 (strongly disagree) to 5 (strongly agree) Likert scale.

The questionnaires were reviewed and edited by a chemical education faculty member and several experienced graduate students not associated with the course prior to the administration of the questionnaire.

Results

Results from Graduate Instructors

The response frequencies for statements specific to either the trial or the control group were summarized and reviewed for obvious patterns (Table 3). The graduate instructors' responses to statements common to both groups were analyzed for significant differences in averages using 2-way analysis of variance (ANOVA). Table 4 lists the statements for which the difference in means was statistically significant at or below the 10% level of probability. Statements for which difference in averages was not statistically significant between groups but response patterns revealed useful information are listed in Table 5. The *n* values differ among statements because not all graduate instructors responded to each statement.

The graduate instructors in the trial group rated the weekly staff meetings as more helpful than the control group and the micro-workshop activities as helpful and applicable in their recitations. The selection of problems to be used in recitations, however, was rated more helpful than the micro-workshops. Of particular note is the high percentage of both trial (81%) and control (89%) group graduate instructors who plan or hope to use active learning strategies in future teaching assignments.

Responses summarized in Table 3 indicate that in general, students cooperated with graduate instructors in both groups. Instructors reported that students in the trial group helped each other more than students in the control group. This is encouraging from the trial perspective because many of the students in the course have had very little previous experience working in cooperative or collaborative groups.

Instructors in the trial group rated faculty and staff support for improvement of their teaching skills higher than did instructors in the control group. When this information is combined with notes taken throughout the semester, it is clear that this type of continuous development activity requires a strong commitment from faculty who are willing to proceed despite the active and passive resistance exhibited by some graduate instructors during the semester.

Of particular interest was the finding that the trial group of instructors disagreed with the idea of having future micro-workshops during staff meetings even though they felt that weekly staff meetings were helpful in improving their teaching. In contrast, 89% of the control-group instructors expressed

Table 3. Graduate Instructors' Responses to Statements

Statement	*n*[a]	Frequency Response on Likert Scale[b] (%)							Mean Score	Variance
		1	2	3	4	5	6	7		
Trial Group										
The micro-workshops during staff meetings provided me with a variety of skills/tools/techniques that I could apply to my recitation.	24	4	17	4	29	25	17	4	4.2	2.3
Overall, I could apply the concepts we practiced during the micro-workshops in my recitations.	26	0	8	15	27	38	4	12	4.4	1.6
I hope to be able to use the active learning techniques we used this semester in future recitations to which I am assigned.	25	0	4	0	15	27	27	27	5.5	1.6
Helpfulness of the individual micro-workshops										
a. Teaching techniques/role playing was helpful.	24	0	0	14	33	42	13	0	4.6	0.8
b. Pre-recitation preparation was helpful.	24	4	8	17	16	38	17	0	4.2	1.9
c. Connecting concepts was helpful.	24	0	16	8	28	20	20	8	4.4	2.3
Selecting problems for recitation that were similar to but different from homework assignments helped me to work with the students to reinforce lecture topics without just doing the students' homework.	26	4	0	4	12	27	35	19	5.4	1.9
The majority of my students willingly participated in group work during recitations.	26	8	12	12	4	19	46	0	4.5	3.1
Control Group										
In the future I would like to use techniques that get my students involved and working during recitations.	19	0	0	6	6	28	28	33	5.8	1.3
The majority of my students willingly participated in recitations.	19	0	11	11	16	47	16	0	4.5	1.5

[a] Number of graduate instructors responding.
[b] Likert scale: 1 = strongly disagree, ..., 7 = strongly agree.

Table 4. ANOVA for Graduate Instructors' Responses to Common Questions

Statement	Group	n^a	Mean	Variance	F	p
The majority of my students helped each other understand problem-solving processes during recitations.	Trial	26	5.2	1.2	5.22	.03
	Control	19	4.4	1.5		
The faculty and staff provided support for improving my teaching skills.	Trial	26	5.3	1.8	3.96	.05
	Control	19	4.5	2.6		
Weekly staff meetings were helpful in improving my teaching effectiveness.	Trial	25	5.1	2.4	3.75	.06
	Control	19	4.2	2.6		
In the future I would like to have a micro-workshop (as part of normal weekly staff meetings) that would give me more tools to use during recitation to help me become a more effective instructor.	Trial	26	3.2	3.5	3.84	.06
	Control	19	4.4	4.0		

[a] Number of graduate instructors responding.

a desire to have micro-workshops during staff meetings.

Even though some of the group differences in responses to statements in the questionnaire were not statistically significant (Table 5), patterns for the trial and control groups revealed trends that we believe inform our efforts. Both groups rated the department orientation as effective in providing them with teaching skills. A majority of all graduate instructors, 59% of the trial group and 78% of the control group, reported that they talked to other graduate students about teaching techniques. We could not control for sharing of information between trial- and control-group instructors throughout the semester, since all the first-year graduate instructors shared office spaces. A review of student responses suggested that eight of the control-group instructors used active-learning strategies in their recitations. Of these eight, seven were first-year graduate instructors. End-of-semester responses from both groups of graduate instructors support the comment made during the trial group's third micro-workshop that behavior problems were minimized with interactive work. The 42% agreement in responses by the control group also correlates with anecdotal information and student feedback indicating that some control-group instructors were implementing interactive work in their recitations in order to have better command of the activities or to minimize some potentially disruptive behaviors. There was no difference between the trial and control group responses regarding the usefulness of attending lectures ($F = 0.06$, $p = .81$).

Student Responses

Students responded to a 29-item questionnaire using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The responses of the students were scored by the university and we received a list of average responses for each statement by section. Without the individual raw score from each student the best we could do was to use section averages for the statistical analysis of student data, which reduced the power of the analysis. To compensate for loss of power, the level of significance for differences between the trial and control groups was calculated and the statements were ranked by this value for the purpose of detecting any useful groupings of statements.

The 53 sections in the trial group represent 1048 students; the 36 sections in the control group represent 689 students. Comparisons of the averages of the section averages were made using 2-way ANOVA. Analysis of student responses is shown in Table 6. All differences favor the trial group.

From the students' perspective the graduate instructors did implement active-learning techniques. Graduate instructors in the trial group were rated significantly higher than those in the control group in areas of preparedness, understanding of material, clarity of explanation, and encouraging development of thinking and problem-solving skills. Students in the trial group gave higher ratings for the overall performance of their graduate instructors than did students in the control group.

Course Supervisor's Notes

It took about four or five weeks before graduate instructors in the trial group really internalized the fact that the faculty were indeed committed to this process of interactive teaching for the entire semester. Some instructors maintained a passive resistance to attending lectures throughout the semester—some would sign the attendance sheet and leave; others would sit through lectures but be involved in some other task. The body language of several graduate instructors reflected very active resistance in micro-workshops and during discussions at weekly meetings.

Workshop activities based on challenging chemical content seemed to decrease participation by chemistry graduate students. Whether through fear of revealing ignorance in the field or some other factor, graduate instructors did not interact

Table 5. Frequency Distribution of Answers to Selected Questions

Statement	Group	n^a	Frequency Response on Likert Scale (%)							Mean Score	Variance
			1	2	3	4	5	6	7		
The department's TA orientation in August provided me with the skills to be effective in recitation.	Trial	25	4	4	4	24	36	28	0	4.8	1.6
	Control	16	5	0	0	19	44	25	6	4.9	1.8
I discussed recitation teaching techniques with other graduate students.	Trial	25	8	4	8	20	16	15	28	4.9	3.6
	Control	19	0	5	11	5	26	47	5	5.2	1.7
Potential disruptive student behavior was minimized by having students actively participate in recitation.	Trial	26	4	8	4	19	38	8	19	4.8	2.6
	Control	19	0	11	16	32	16	21	5	4.4	2.0

[a] Number of graduate instructors responding.

Table 6. ANOVA of Section Averages for Student Responses

Statement	Group	n^a	Mean	Variance	F	p
My TA often had the students answer questions or solve problems during recitations.	Trial	53	4.4	0.5	22.2	9×10^{-6}
	Control	36	3.7	0.5		
The TA's answers or explanations are clear.	Trial	53	3.7	0.5	4.18	.04
	Control	36	3.3	0.7		
The TA understands the material he or she is trying to teach.	Trial	53	4.2	0.2	3.13	.08
	Control	36	4.0	0.4		
My TA encouraged students to focus on the work being done during recitations.	Trial	53	3.8	0.5	2.34	.13
	Control	36	3.6	0.4		
The TA motivates me to think.	Trial	53	3.6	0.3	2.08	.15
	Control	36	3.4	0.4		
On a scale from 5 (excellent) to 1 (failing), I would give this TA:	Trial	53	4.0	0.4	2.10	.15
	Control	36	3.8	0.6		
The TA helped me understand the course material.	Trial	53	3.7	0.4	1.67	.20
	Control	36	3.5	0.6		
The TA seems well prepared for class.	Trial	53	4.0	0.3	1.2	.28
	Control	36	3.9	0.3		
My TA presented approaches, methods, and skills that helped me become a better problem solver.	Trial	53	3.5	0.7	1.16	.28
	Control	36	3.3	0.4		

[a] Number of sections.

cooperatively when given a very challenging chemical problem. Sharing of questions, answers, ideas, or procedures was extensive and lively with noncontent problems or activities appropriate for general chemistry.

Graduate instructors in the trial group seemed surprised that their peers approached or presented a solution to a problem in ways different from their own. This reinforced our emphasis that students learn in various ways.

As the semester progressed, it appeared that graduate instructors in the trial group became more skilled than those in the control group at judging the accuracy and appropriateness of the variety of strategies students used in their written explanations and problem solving on quizzes and lab reports. The control group TAs were more focused on "the correct way".

As the semester progressed, more talk and interaction among graduate instructors was observed during the weekly meetings of the trial group than the control group.

During the feedback process of the third workshop in the trial group, graduate instructors indicated that they felt that behavior problems in their recitations were alleviated by having students work together.

The nature of student complaints made to the course supervisor about the trial-group graduate instructors differed from those about the control group as the semester progressed. The number of complaints were few, but the most common complaint from the trial group was that the instructor "wasn't doing his/her job by not working the homework problems for me during recitations" or that the instructor "wouldn't give me the answers to the problems". The most common student complaint about the control-group instructors related to grading issues.

Graduate instructors' attention and involvement in a teaching micro-workshop were limited when they had an exam in the near future.

Trial-group graduate instructor comments indicated that recitations were more fun when students were working together and that the time in recitation went by quickly. Control group graduate instructors spoke of "time dragging" in recitation as they waited for students to ask questions.

Discussion

Birk and Foster (*5*) found that little substantial student learning occurs as a result of attending chemistry lectures. Attending regular faculty lectures and yet another lecture in recitations does not meet the needs of students having a variety of learning styles as they attempt to master general chemistry. In fact, a recent study (*6*) found that the traditional lecture format was useful for communicating some information but it was not the students' preferred mode of learning. We have found a similar agreement. Students in both the trial (mean = 2.8) and control (mean = 2.9) groups on average disagree with the statement "I prefer the traditional lecture approach in recitation rather than group work." It was our hope that from the interactive experiences in recitation students would recognize the benefits of studying in groups and form chemistry study groups outside the regularly scheduled class times. The average response to the statement "I regularly study with a group for CHM 115 outside of class (5 = yes; 4 = no)" was 4.2 for both the trial and control groups. Thus it was difficult to assess if the interactive work affected work *outside* the classroom, but it appears that students prefer to have some active group work *in* the classroom. Consequently, recitations could most certainly be useful in enhancing learning, but a change in practice and attitude about how recitations are conducted must take place.

Asking graduate instructors to devote more time to teaching activities at a research institution can be perilous, so any model for continuous development must be sensitive to the commitments graduate instructors have to their classes and research. Results from our graduate and undergraduate students are encouraging and reinforce our belief that change can be fostered by using a model of continuous development after the department's fall orientation. These findings are consistent with the results reported by Birk and Kurtz (*7*).

It appears that a multifaceted continuous development program (use of staff meetings for interactive work and discussion on classroom and learning issues, preparation for recitation, faculty involvement and support) can be used effectively to facilitate improvement of graduate instructors' teaching skills with minimal disruption in their schedules and minimal demand on their time. However, feedback from graduate instructors indicates that micro-workshops during staff meetings need to involve general chemistry or noncontent material, be very focused for the short amount of time available, and be limited in number. There are several possible explanations for the responses of the trial-group instructors that they did not want to have micro-workshops during staff meetings even though they also reported that the micro-workshops helped their teaching. They may feel that they have acquired sufficient skills to be effective as graduate instructors. The activities done throughout the semester may have reached their tolerance limit to address education-related issues. It is also possible that they *would* like more workshops, but not during staff meetings, since those issues were unfortunately confounded in the statement on the questionnaire.

It was risky to expect 27 graduate instructors (and 1100 students) to change their behaviors to something that likely conflicted with their personal, self-defined classroom roles for individuals. Even more challenging was to get graduate instructors to change their ideas of themselves as teachers—ideas which, in large part, are modeled on personal classroom experiences. Short-term or immediate, observable results proved more effective in getting graduate students to "buy in" to a change in attitude toward and practice of what is involved in good teaching than the projection of future professional needs. Most graduate instructors were "hooked" by their experiences, which were described as more fun, and the perception that recitations "went faster" than when they were at the board doing all the talking, explaining, and problem solving. Some did not seem to be able or want to change, and the active resistance observed at the beginning of the project changed to passive resistance toward the end of the semester.

It is noteworthy that 17 of 24 trial-group and 7 of 19 control-group instructors reported a preference to take a course that uses group or cooperative strategies rather than lectures only. However, translating personal experiences and preferences as a student into behavior as a teacher is not a straightforward process. Although the section averages for the trial group reveal that only one graduate instructor received a very low rating on the statement "My TA often had the students answer questions or solve problems during recitations", the data suggest that three instructors in this group were merely going through the motions of having students work in small groups during recitation, without following through with interactive strategies of coaching and guiding. On the other hand, the responses from the control-group students to this question reveal that eight instructors in the control group had students actively involved during recitations.

This work does not provide definite predictors for success with future graduate instructors. However, it does encourage us to continue pursuing a continuous-development model that deals with teaching issues and guidance when the needs arise and is also sufficiently flexible to deal with the "real-time" issues graduate students need to have addressed—not what a seminar speaker presents. A positive result of this study is that the faculty at Purdue University unanimously approved the implementation of continuous-development activities for all Chemistry 115 graduate instructors. We have found that it is important in any ongoing endeavor to obtain feedback and information, formal or informal, from the graduate instructors themselves and to be able to respond to their needs in a timely manner. If we can begin to change the department graduate-instructor "culture" in relationship to what is involved in teaching and learning, we may see more success and in the long term be able to move our general chemistry students further toward taking responsibility for their own learning.

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