Marbach-Ad, G., Schaefer, K. L., & Thompson, K. V. (2012). Faculty teaching philosophies, reported practices, and concerns inform the design of professional development activities of a disciplinary teaching and learning center. *Journal on Centers for Teaching and Learning, 4*, 119-137.

Faculty Teaching Philosophies, Reported Practices, and Concerns Inform the Design of Professional Development Activities of a Disciplinary Teaching and Learning Center

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This study explored faculty members' teaching philosophies, reported practices, and concerns at a research-intensive university. This information was used to shape the goals and activities of a disciplinary Teaching and Learning Center within a College of Chemical and Life Sciences. Fifty-eight faculty members responded to a survey. The authors found that faculty members expressed teaching philosophies and goals that largely correspond to national recommendations; however, most of them reported still relying extensively on lecturing, the same predominant teaching method they experienced as undergraduates. The survey results helped tailor professional development activities to faculty members' beliefs, practices, and concerns.

Introduction

This study explored faculty members' teaching behaviors and beliefs at a research university, which were then used to shape the goals and activities of a newly developed disciplinary Teaching and Learning Center (TLC) in the College of Chemical and Life Sciences (CLFS). Tagg (2010) recognized three types of relationships between teaching and learning centers and the teaching faculty at an institution: (1) The center strives to serve the needs of the faculty by addressing pressing issues; (2) the center provides professional consultation to faculty who seek out assistance; and (3) the center establishes goals in advance and seeks to achieve them. Our teaching and learning center incorporates all three of these relationships. We created the center with the main goal of promoting a culture that values and studies excellent teaching and learning, but we attend to pressing needs as well as offering consultation.

In most institutions, teaching and learning centers are institution-based, serving the entire university community. We developed a disciplinary TLC to serve the needs of chemistry and biology faculty members, based on the idea that faculty members' disciplines tend to shape their teaching behaviors more than do the norms of and connections to their institution (Fairweather, 1996). The disciplinary focus of our center makes it a powerful model for faculty professional development.

One of the advantages of a disciplinary TLC is the ability to build professional development activities around the special requirements for teaching a particular discipline, using Pedagogical Content Knowledge (PCK). PCK represents the integration of the relevant content and best pedagogical practices for that content (Shulman, 1986). Effective teachers understand what makes it easy or difficult to learn specific content and what preconceptions and misconceptions students typically hold (Major & Palmer, 2006; Shulman, 1986; van Driel, Beijaard, & Verloop, 2001). PCK requires a level of understanding that is only achieved through thoughtful and purposeful engagement in teaching (Major & Palmer, 2006; Shulman, 1986; van Driel et al., 2001).

Several studies have explored the application of PCK to teaching in the sciences. These studies found that familiarity with a specific topic in combination with teaching experience contributes positively to PCK (van Driel et al., 2001; van Driel et al., 1998). In addition, research indicates that helping prospective instructors study subject matter from a teaching perspective can enhance their teaching methods and instruction (Clermont, Borko, & Krajcik, 1994; Lederman, Gess-Newsome, & Latz, 1994). One way to assist instructors in the development of PCK is through disciplinary teaching and learning professional development activities.

In accordance with PCK, there is also widespread agreement that student-centered strategies (for instance, active learning through problem solving and inquiry-based learning) are more effective than teacher-centered strategies (for instance, listening, reading, rote memorization) in helping students attain deep, lasting understanding and well-developed scientific reasoning skills (Fink, 2000). However, faculty members tend to be satisfied with traditional instruction and remain skeptical of other methods (Hanson & Moser, 2003; Hativa, 1995; Henderson, Beach, Finkelstein, & Larson, 2008; Luft, Kurdziel, Gillian, Roehrig, & Turner, 2004; Miller, Martineau, & Clark, 2000). Faculty members come to the university with diverse beliefs, intentions, and attitudes (van Driel et al., 2001), especially in relation to the nature of specific subject matter (Grossman & Stodolsky, 1994). The development of these beliefs, intentions, and attitudes appears to be based on past experiences. According to Anderson and Helms (2001), the beliefs, intentions, and attitudes of teachers are the result of their own undergraduate education and their experience in professional development activities throughout their careers. Thus, new faculty members often come to their positions with a preformed teaching philosophy. These teaching philosophies represent important areas to explore, as they can impact teaching practices and student achievement (Adamson et al., 2003; Brickhouse, 1990; Cronin-Jones, 1991; Gallagher & Richmond, 1999; Munby, Cunningham, & Lock, 2000; Tobin & McRobbie, 1996). Since many faculty members mainly experienced the traditional lecture style as students, they tend to replicate this type of teaching in their own classrooms (Adamson et al., 2003).

While heavy reliance on lecturing is at odds with the national recommendations to reform science education (American Association for the Advancement of Science [AAAS], 2011; Association of American Medical Colleges, 2009), these long-held teaching beliefs and practices are often resistant to change. Therefore, we found it important to assess faculty members' teaching philosophies and concerns so that appropriate professional development activities could be offered. To gain a better understanding of the current views and practices related to teaching among our faculty, we established the following research goals:

1. Identify instructors' teaching philosophy and educational goals.
2. Explore which teaching practices instructors are using.
3. Investigate instructors' perceived challenges in balancing competing responsibilities.

The CLFS Teaching and Learning Center

At the time of this study, our university enrolled 25,590 undergraduate and 9,742 graduate students in 111 undergraduate and 96 graduate programs. Within the College of Chemical and Life Sciences, there were 150 faculty members (34% of them female), about 2,200 undergraduates pursuing majors in the Biological Sciences, and about 400 undergraduates pursuing majors in Biochemistry and Chemistry. Over the preceding decade, substantial institutional investments in bioscience research and instruction were made to ensure that the undergraduate curriculum could reflect the rapid growth of knowledge in this field.

During the summer of 2005, the College underwent an external review of its Howard Hughes Medical Institute (HHMI) Undergraduate Science Education programs. The review process included five groups of faculty members and graduate students engaged in curriculum enhancement projects. One theme that emerged from the external review was that graduate students, in particular, felt unprepared for their involvement in revising courses. Similarly, faculty were often unaware of national Science, Technology, Engineering and Mathematics (STEM) education reform efforts that were complementary to the goals of their curriculum projects. Based on the recommendations of the external review committee, the College, in coordination with the campus Center for Teaching Excellence (CTE), decided to create more structured opportunities for both faculty and graduate students to learn about innovative teaching approaches and trends in STEM education. The CLFS Teaching and Learning Center (http://cmns-tlc.umd.edu/tlc) was established in 2006 with funding from a new HHMI grant. The overarching goals of the Center are to (1) make training in teaching science part of the standard graduate program alongside training in scientific research, (2) provide opportunities for science faculty to collaborate and consult with science education experts, and (3) create a structured environment of teaching and learning communities to support faculty in their efforts to identify appropriate content and adopt effective pedagogies. We work closely with the campus CTE and the Office for Information Technology so as to extend, rather than duplicate, their efforts.

Activities of the Center have included (1) workshops for informal discussion of teaching issues, (2) a formal course for entering graduate students that prepares them to teach laboratories and lead discussion sections for introductory biology and chemistry courses, (3) teaching seminars by visiting teacher/scholars who have been nationally recognized for their ability to integrate teaching and research, to provide role models for current and future faculty, (4) travel grants to allow faculty and graduate students to attend workshops and national conferences on teaching and learning, and (5) working closely with individual faculty to develop innovative teaching approaches, assess the impact of these innovations on student learning, and present their results at science education annual meetings and in science education journals.

Most significantly, the TLC has catalyzed the establishment of a variety of faculty teaching and learning communities (FLCs; Cox, 2004; Dawkins, 2006; Layne & Froyd, 2006; Silverthorn, Thorn, & Svinicki, 2006; Sirum, Madigan, & Klionsky, 2009) that facilitate curriculum redesign and support faculty in their efforts to adopt innovative teaching strategies. Faculty teaching and learning communities focus variously on thematically linked sequences of courses in the upper-level curriculum, gateway introductory courses, and the interface between related science disciplines (for example, biology/mathematics, biology/physics).

The TLC is staffed by two individuals. The Director is a science educator by training and serves as a bridge between the disciplines of science and education. She develops programming, teaches graduate courses in pedagogy and instruction, and provides individualized guidance to faculty. A graduate assistant provides additional support for program development and assessment. Importantly, the TLC also relies on the engagement of faculty members from across the College, especially lecturers, who are taking major roles in leading FLCs and helping to create systematic mentoring programs.

Methods

Research Instrument

To address our research goals, we developed a survey using selected questions derived from the Higher Education Research Institution (HERI; http://www.heri.ucla.edu/) Faculty Survey and from a previous study by the TLC director (Marbach-Ad & Arviv-Elyashiv, 2005). The HERI survey probes faculty members' experiences, attitudes, satisfaction, and teaching practices and is designed specifically for professional development program evaluation (http://www.gseis.ucla.edu/heri/facoverview.php). The HERI has been in use for 20 years, and in that time has been administered to >300,000 faculty at more than 1,100 participating institutions. The Marbach-Ad and Arviv-Elyashiv (2005) survey instrument is specific to science disciplines. It was used in Israel to identify faculty teaching goals and attitudes towards science teaching. It has also been used to gauge faculty members' use of new innovations in their teaching and their perceived challenges to the implementation of innovative teaching practices. Face validity of the survey was established using science education faculty members both inside and outside the university.

In spring 2009, the survey was administered online and anonymously to all CLFS faculty members ($N = 150$).

Participants

Fifty-eight faculty members completed the survey. All faculty ranks were represented in the sample, in proportions roughly equivalent to their representation in the college (22% professors, 28% associate professors, 22% assistant professors, 24% lecturers, 2% adjunct faculty, and 2% other). The gender composition of the sample was 28% females, 62% males, and 10% unknown. Faculty responded roughly in proportion to their representation in the four departments that constituted CLFS. The overall response rate for the survey was approximately 39%. We attribute the high level of response to active encouragement by the dean that faculty members take the survey.

Data Analysis

The survey included a variety of question types, including Likert-scale questions, multiple-choice questions, and open-ended explanations. We used a mixed-methods analysis. Responses to the open-ended questions were analyzed qualitatively using an inductive approach (Maykut & Morehouse, 1994), in which we grouped related responses into subcategories that could be quantified. A graduate student from the College of Education and a science education faculty member categorized the responses separately and then discussed their categories until they came to agreement. Their interrater agreement was 90%. The quantitative data were obtained from the Likert-scale and multiple-choice questions. Data were analyzed with correlational, chi-square, and *t*-test analyses.

Findings

We report here our findings according to our research goals.

1. Identify instructors' teaching philosophy and educational goals.

Faculty members were asked to describe their teaching philosophy in one or two sentences. Our categorization of the key concepts from their responses is shown in Table 1.

Many faculty members (47.7%) cited examples of critical thinking in their description of their teaching philosophy (Table 1). These included strategies such as problem-solving, application from one situation to

Table 1
Categorization of Faculty Members' Description of Their Teaching Philosophy (*N*=44)

Teaching Philosophy	*Percentage**
Critical thinking	47.7%
Students engagement and working in groups	20.5%
Affective (fun, enjoy, etc.)	18.2%
Connection to everyday life	15.9%
Other	13.6%
Depends on students' prior knowledge	6.8%
Passing on knowledge	6.8%

*Note: Percentages sum to more than 100% because faculty responses could fall into more than one category.

another, quantitative thinking, scientific teaching and learning, communicating knowledge to others, and interdisciplinary teaching. About one fifth of the faculty members (20.5%) promoted student engagement and working in groups. One faculty member wrote, "My ultimate goal is to make myself obsolete by equipping students with the desire and ability to learn on their own and with their peers." Eighteen percent of faculty members related to the students' affect. One faculty member wrote, "The goal of my teaching [is] to attempt to design courses that encourage students to experience the joys and wonders of biology and biological research." Some of the faculty members (15.9%) wrote about the importance of connecting class material to everyday life. One participant wrote, "I try to show students how what they are learning in the class will apply to their roles as educated citizens and voters for the rest of their lives." Few faculty members (6.8%) provided examples of how they adjust their teaching style according to students' prior knowledge.

Another question asked faculty members to rate the importance of different education goals for undergraduate students (see Table 2) on a 6-point Likert scale from 1 (*not at all important*) to 6 (*very important*). We analyzed the data, collapsing categories 5 and 6. Interestingly, when we asked faculty members directly about teaching critical thinking, all indicated that this was of highest importance. Faculty members also endorsed as very important students' abilities to evaluate the quality and

Table 2
Distribution of Faculty Members' Responses to the Question, "Indicate the Importance to You of Each of the Following Education Goals for Undergraduate Students." (*N* = 58)

Educational Goals	*Percentage Choosing 5 or 6 on a 6-Point Scale of Importance*
Develop ability to think critically	100 %
Evaluate reliability of information	93.1%
Understand the dynamic nature of science	74.1%
Develop creative capacities	70.7%
Promote the ability to write effectively	69.0%
Increase motivation to continue in science	67.9%
Prepare students for graduate education	65.5%
Understand the applicability of science	63.8%
Master knowledge in a discipline	55.2%
Prepare students for employment	48.3%
Help students acquire laboratory skills	48.2%
Know the history of science	21.1%

reliability of information (93.1%), to understand the dynamic nature of science (74.1%), to develop creative capacities (70.7%), and to write effectively (69%). We recognize that all of the above goals embody the desire to promote higher-level thinking. The faculty members were less likely to choose as very important students' ability to achieve the following goals: mastering knowledge in the discipline (55.2%), acquiring laboratory skills (48.2%), and knowing the history of science (21.1%). This finding is encouraging, because these findings are in alignment with recent national recommendations (AAAS, 2011; National Research Council, 2003; National Science Foundation, 1998) to focus on promoting students' critical and higher-level thinking (Bloom, 1984) over content coverage and memorization. These ideas have been reinforced by the college administration and the TLC through its activities.

2. Explore which practices instructors are using.

It is often asserted that instructors tend to teach in the same way that they were taught (Adamson et al., 2003). To explore this assertion, we asked the faculty members to reflect on the way that they were taught in their undergraduate studies as well as to describe the practices that they currently use in the classroom (see Table 3). Participants responded on a 4-point scale regarding how often they were exposed to and how often they currently use various teaching techniques (with 1 = *never*, 2 = *infrequently*, 3 = *sometimes*, and 4 = *very often*).

Extensive lecturing was the most commonly reported practice that faculty members were exposed to as undergraduates (Table 3), and it remained the most commonly reported practice used by faculty in their own classrooms, despite recent national recommendations for more student-centered teaching approaches. Not surprisingly, very few faculty members reported that as undergraduates they were exposed to the use of technology in the classroom, such as electronic quizzes with immediate feedback (2%), Personal Response Systems (clickers) (2%), online forums (2%), and multimedia instruction (10%). Faculty members reported using these teaching practices in their classrooms significantly more often than expected based on the frequency with which they encountered these practices as undergraduates (Table 3). The current popularity of these practices may stem from growing campus and national efforts to encourage the use of technology in teaching. Faculty also reported using real-life problems more often in their current teaching than expected based on their undergraduate exposure to this teaching strategy. We believe that this finding reflects the recent emphasis on the value of using case studies in the classroom (Allen & Tanner, 2003; Chamany, Allen, & Tanner, 2008) and the wealth of available teaching resources and conferences that assist faculty with developing and implementing case studies in science teaching (see, for example, http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm).

On the other hand, there were several teaching practices that were used less frequently than expected based on the frequency with which faculty members encountered these practices as undergraduates. These were experiential learning (undergraduate = 47%; current teaching = 22%), written work (undergraduate = 45%; current teaching = 14%), and directed research (undergraduate = 62%; current teaching = 27%). It is

Table 3
Comparison of Faculty Responses to Teaching Methods Experienced as an Undergraduate and Used as an Instructor (Paired *t*-Test Analysis)

	As an Undergraduate (N = *58*)		*As an Instructor* (N = *57*)		
Teaching Method	**Sometimes/ Very Often**	**Mean**	**Sometimes/ Very Often**	**Mean**	**Significance**
Extensive lecturing	97%	3.86	95%	3.61	$p < .05$
Class discussions	72%	2.89	71%	2.86	NS
Real-life problems	17%	1.80	66%	2.68	$p < .001$
Cooperative learning	43%	2.29	55%	2.45	NS
Multimedia	10%	1.55	54%	2.52	$p < .001$
Group projects	45%	2.16	42%	2.09	NS
Online forums	2%	1.14	32%	1.96	$p < .001$
Electronic quizzes	2%	1.07	27%	1.86	$p < .001$
Clickers	2%	1.05	27%	1.80	$p < .001$
Directed research	62%	2.71	27%	1.82	$p < .001$
Experiential learning	47%	2.31	22%	1.59	$p < .001$
Student-developed activities	26%	1.98	20%	1.69	NS
Student-selected topics	12%	1.61	14%	1.66	NS
Written work	45%	2.29	14%	1.54	$p < .001$
Games	2%	1.29	14%	1.57	$p < .05$
Journaling	16%	1.64	7%	1.21	$p < .001$

possible that large class sizes and budgetary constraints preclude the frequent use of written assignments (essays and open-ended questions) because they typically are more time-consuming to grade than multiple-choice assessments. Some of the differences between past experiences and current practices (for example, experiential learning and directed research) may also be attributable to how the survey questions were worded, in that faculty may have been recalling their undergraduate experience as a whole, but reporting on teaching approaches for only the small subset of classes that they currently teach.

3. Investigate perceived challenges in balancing competing responsibilities.

One of the challenges for faculty members, especially at a research university, is balancing all of their roles and responsibilities, such as teaching, research, and mentoring. We asked the faculty members to report on their various responsibilities. Thirty-three percent reported having only teaching responsibilities, 2% were doing only research, and 65% reported having both teaching and research responsibilities. Most of those who had both teaching and research responsibilities (66.7%) were concerned about doing both of these activities well. One faculty member wrote, "It is not easy to do well on both [research and teaching], and requires so much energy and time." Another wrote, "This is a constant struggle, and both [research and teaching] are short changed."

The survey also assessed whether faculty members feel they achieve a healthy balance between their personal and professional life. Forty-three percent reported that they do achieve a healthy balance, whereas 52% reported that they do not. One faculty member who reported achieving a healthy balance wrote, "I make sure to take time during the week to relax and decompress." Faculty members who felt that balance was a challenge wrote, "Always a struggle. Wish I could do better on both fronts," or "No, life is generally one or the other. Some weeks I am more home-focused, and other weeks I am more work-focused."

Discussion and Implications

Our Teaching and Learning Center addresses a pressing national need by providing an infrastructure for faculty interested in adopting innovative teaching strategies and improving the undergraduate science curriculum. We feel the TLC's effectiveness derives from its disciplinary focus. *Disciplinary* teaching and learning centers have the potential to play a key role in faculty professional development because they use the language of the faculty's discipline (Alpert, 1985; McShannon & Hynes, 2005) and have a large impact on faculty behaviors (Henderson, 2007). As part of our desire to tailor professional development activities of the TLC to faculty beliefs, practices, and concerns, we designed and administered a survey to characterize their teaching philosophies, behaviors, and perceived challenges.

The survey was distributed without any monetary incentive for participation and was anonymous; however, we believe that the involvement of the dean in requesting participation in the survey helped ensure a high response rate. In addition, the Director of the TLC visited departmental meetings to introduce the TLC and promote the upcoming survey. This allowed the TLC to receive wider exposure and demonstrated that the department chairs and dean placed a high value on teaching.

The survey indicated that faculty members expressed teaching philosophies and goals that correspond largely to national recommendations, for example, emphasizing critical thinking over mastery of facts as a major goal for undergraduate studies. Some faculty members also stressed the importance of student engagement as a teaching philosophy. However, even though faculty members were aware that critical thinking and student engagement are important, they still relied extensively on lecturing, the same predominant teaching method they experienced as undergraduates. Similar findings were reported by Henderson and Dancy (2008). Tagg (2010) compared faculty members to students, in that even when faculty members value innovative teaching approaches, they do not always practice them in their classroom—just as students may aspire to achieve a deep level of understanding, but rely heavily on rote memorization rather than engaging in learning practices that promote deep learning.

We believe that one reason for this discrepancy between faculty beliefs and practices is that most faculty lack formal training in teaching, which creates a barrier to the incorporation of new practices in the classroom. Teaching expertise and confidence can be enhanced through formal graduate coursework for future faculty, seminars and workshops, mentoring/modeling, or reading science education literature. Therefore, with the TLC we aimed to offer a wide array of programs that make this type of training more available to STEM faculty in ways that are useful and encourage their participation.

In developing TLC programming, we deliberately used an organizational model that parallels the practice of science, making it familiar and accessible to science faculty. Faculty can attend workshops to learn new skills. They can learn about current developments in science education and interact with the broader science education community by attending national conferences and seminars by visiting experts. Graduate students are considered integral members of our teaching community, are welcomed at all TLC activities, and are provided with formal instruction in teaching as part of their training. Most importantly, faculty and graduate students are strongly encouraged to contribute to the advancement of knowledge by disseminating their teaching innovations in peer-reviewed journals. All of these activities are standard practices in science research that are becoming part of our institutional teaching culture.

TLC workshops focus specifically on topics most relevant to STEM education. For example, one recent workshop focused on the origin and characteristics of students' alternative conceptions (sometimes referred to as misconceptions) regarding basic science phenomena. This workshop resonated with our faculty because many have had the experience of trying to help students achieve a more sophisticated understanding, only to see the students revert to incorrect or naive conceptions. The workshop introduced ways to address these alternative conceptions in the classroom, for example, by following the recommendations of Handelsman, Miller, and Pfund (2007) and Wiggins and McTighe (1998) and using backwards design (that is, identify desired learning goals and outcomes, determine evidence for learning, then plan learning experience and instruction).

Our Visiting Teacher/Scholar seminar series highlights scientists who are nationally recognized for their ability to integrate teaching and research. Visiting Teacher/Scholars spend two days on our campus sharing their ideas and meeting with small groups of faculty for informal discussion. They typically give two formal seminars, one focusing on teaching innovations and one focusing on their scientific research. We feel that this dual emphasis on teaching and scientific research helps broaden our audience, as faculty members who otherwise would be unlikely to attend a seminar by a teaching specialist might be drawn in by a similar presentation by one of their scientific colleagues. Time is specifically set aside for meeting with graduate students. Our hope is that the Visiting Teacher/Scholars will serve as role models for our graduate students and new faculty for how to achieve a balance between teaching and research. This is particularly important because our findings indicate that faculty struggle with finding this balance.

The TLC also provides advice and logistical support for faculty learning communities (FLCs), in which faculty with similar teaching interests collaborate to work on curriculum, pedagogy, and assessment. Cox (2004) described how FLCs represent an active, collaborative, continuous process of learning and reflection that is supported by colleagues. Our communities provide many benefits to participating faculty, including regular opportunities to discuss classroom issues, individual mentoring in teaching, a supportive environment for obtaining ideas and feedback, and the opportunity to collaborate on large-scale initiatives that might be daunting to a faculty member working alone. Our current FLCs are organized around a variety of themes, including gateway courses, linked sequences of courses, and interdisciplinary teaching. In one FLC, for example, faculty responsible for nine undergraduate microbiology courses regularly discuss how to create a learning progression for the students, using a spiral learning approach that provides reinforcement of knowledge from prior courses while avoiding excessive repetition and challenges students to think at a higher level. This community created an assessment tool (concept inventory) that helps to monitor how well students retain concept knowledge from previous courses as they progress through subsequent courses (Marbach-Ad et al., 2007, 2009, 2010a). The success of this community's efforts supports Tagg's (2010) assertion that collaboration between instructors is vital to helping students learn to transfer knowledge from one course to another.

One current TLC initiative that has resulted from our efforts to understand faculty needs and concerns is the development of formal processes for peer review of teaching. We are working closely with department chairs and faculty to develop an evaluation framework that can be used not only for summative purposes (merit and promotion), but also as a regular feedback process in which all faculty members are observed and serve as observers. Using a consensus-building approach, the faculty have developed a rubric based on characteristics they recognize as being hallmarks of effective teaching. The effort is a collaboration among peers in all aspects, from development of the rubric to conducting the observations, which we hope will make faculty more receptive to feedback and more open to trying innovative teaching practices.

The TLC personnel also work with individual faculty members to implement innovative teaching techniques in their classrooms. For example, our survey indicates that written assignments are not used very often in our undergraduate science courses, even though faculty think that effective writing is an important teaching goal. Therefore, the TLC is working with faculty to find ways to make writing assignments more manageable in large classes (for example, using technology, peer review).

Another professional development activity of the TLC has been strengthening training in teaching for graduate students in our college. Our goal was to help break the cycle of over-reliance on lecturing that results from a lack of familiarity and comfort with more innovative, student-centered approaches. In collaboration with faculty from four departments, the TLC developed two 6-week teaching preparatory courses (one in chemistry, one in biology) for all new graduate teaching assistants (Marbach-Ad et al., 2010b; Marbach-Ad et al., 2012). For students interested in more extensive training in teaching, we offer a University Teaching and Learning Program that enables graduate students to earn a certificate and transcript notation. These students are required to enroll in a science education course, attend teaching and learning workshops, observe master teachers in the classroom and be observed teaching, conduct a science teaching project, and prepare a teaching portfolio that contains written reflections on their teaching experience and philosophy. This provides graduate students with excellent preparation for their future academic careers.

Our future goals are to expand TLC activities to better serve the needs of faculty and graduate students and to continue evaluating the impact that these activities have had on our faculty members' enthusiasm for teaching, their ability to adopt new, student-centered approaches in the classroom, and their confidence in their ability to balance their teaching and research responsibilities. We ultimately seek to identify which aspects of the TLC are most influential and can be replicated at other institutions to catalyze science education reform.

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Acknowledgments

We would like to thank Robert Infantino and Michal Orgler for their valuable comments on the manuscript, Mike Landevere for assistance with technology, and faculty members of the college of Chemical and Life Sciences for willingness to participate in this study. The preparation of this manuscript was supported by a grant from the Howard Hughes Medical Institute Undergraduate Science Education Program to the University of Maryland, and by a grant from the National Science Foundation, the Course, Curriculum, and Laboratory Improvement (CCLI) (DUE - 0942020). This work has been approved by the University of Maryland, College Park Institutional Review Board as IRB Protocol #07-0021.

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