

A Model for an Intensive Hands-On Faculty Development Workshop To Foster Change in Laboratory Teaching[†]

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Faculty development workshops are frequently used to bring about change in faculty teaching. Yet, the characteristics of successful faculty professional development in the context of laboratory teaching are unclear. In this Perspective, we describe our approach to intensive hands-on faculty development workshops for fostering change in laboratory teaching and present evidence for the effectiveness of the approach. The outcomes from our workshops and feedback from past participants support the following recommendations: 1) faculty should attend workshops in teams from their institutions, 2) workshops should allow participants to develop curricula that can be implemented with relatively little additional work after the workshop, 3) workshops should allow faculty time to “work” on tangible products and should involve hands-on activities, 4) workshops should be of sufficient duration to allow for faculty to develop expertise and tangible products but short enough that faculty do not “burn out,” and 5) a structure for ongoing and systematic follow-up with participants is essential.

INTRODUCTION

Efforts have been made during the past 20 years to bridge scientific research and science teaching as part of an educational reform movement, spurred on by the Boyer Commission Report, BIO2010, the *Vision and Change* report, and other reports (1–5). One of the core reforms proposed by these efforts is to make science learning and teaching more student-oriented and inquiry-based, as students learn better through self-exploration and discovery, and to help students understand the process of science by conducting research activities. In fact, the *Vision and Change* report (1) calls for research experiences for *all* students. However, providing traditional mentored research experiences for all students is not feasible. Replacing traditional laboratory courses with research courses (4) would permit this goal to be met. Yet, laboratory courses in biology rarely incorporate such experiences (6, 7).

The recognition that faculty instructional practices need to change is not new, but only recently have teaching innovation efforts, including faculty development workshops, and their relationship to change in faculty behavior been

systematically studied. Several recent reviews have detailed the characteristics of successful faculty professional development activities. D’Avanzo (8) identified five key factors that are necessary for successful faculty professional development to improve teaching. Faculty professional development activities should: 1) ensure faculty are collaborators as well as participants in programs to change instructional practices, 2) engage participants in active learning and emulate the instructional practices they hope to foster, 3) provide rewards that faculty value as an embedded outcome of professional development activities, 4) plan for and allow discussion of institutional-specific barriers and facilitators to change, and 5) facilitate work by faculty in groups or teams that can support and encourage each other in the process of change.

Khatri *et al.* (9) focused on the practices of educational innovation developers that led to successful adoption by other faculty in STEM disciplines. Their study concluded with three implications-recommendations for education developers: 1) innovations should be developed in collaboration with the faculty who will be the end users, 2) developers should interact directly with potential adopters (for example, in a workshop), rather than rely on publication alone for dissemination, and 3) developers should provide a means for supporting participating faculty during the process of implementing innovations.

Manduca (10) presented a model of faculty development that includes professional development activities (such as

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workshops) as part of a larger scheme of factors that influence the development of faculty teaching expertise and change in teaching practices. This approach built on the simple model that faculty learn from a professional development activity, leading to improved teaching practices that in turn result in improved student learning outcomes. The observation that development of faculty teaching expertise changes as a consequence of more than professional development activities alone is important, because it suggests that the most effective professional development activities should leverage other factors, such as institutional professional development, past teaching experiences, professional experiences, reading and presentations on teaching, and interactions with colleagues (10).

Most of the recommendations above are based on faculty professional development for curriculum innovation in traditional lecture courses and not laboratory courses. Although implementing pedagogical and curricular changes in lecture and laboratory courses is similar, unique aspects of laboratory courses require different approaches to professional development. Laboratory learning and teaching pedagogies can be described on a continuum from faculty-centered (cookbook) to student-centered (open inquiry), and reform efforts have focused on moving instructional practices toward the student-centered end of the continuum (11, 12). Yet, the numerous approaches to inquiry-based instruction in laboratory courses (13) involve different degrees of change in instructional practices and therefore present different challenges to faculty attempting to change their pedagogy. However, in all cases, faculty need to gain experience with new laboratory and data analysis techniques, in addition to learning new content knowledge and teaching approaches. Furthermore, student assessment in inquiry laboratory courses is often quite different from traditional approaches. Finally, the barriers to implementing new curricula are substantially different for laboratory and lecture courses. Therefore, how general recommendations for faculty professional development apply to professional development related to laboratory teaching is unclear. Thus, in this Perspective, we considered the alignment between faculty development workshops we designed and conducted and the best practices that have been proposed. The workshop model we describe fostered the development and implementation of guided-inquiry laboratory activities by the participants following each of four annual workshops. In addition, we present findings on the efficacy of our workshop model. We report on student outcomes elsewhere (14). Henderson *et al.* (15) noted that change may occur at either the level of individual faculty or at the level of institutions. In the current study, we focused on individual faculty and their teaching practices.

Description of the workshops

We initiated a series of four faculty development workshops with the fundamental goal of having faculty design and

ultimately implement new biology laboratory modules that use the bean beetle model system (16) and were taught using a guided-inquiry pedagogy. Our workshop model falls between prescribed and emergent outcomes at the individual level in the change matrix proposed by Henderson *et al.* (15), as faculty were prescribed in using bean beetles and a guided-inquiry approach, but their laboratory module and exactly how it was implemented in their course emerged from the independent work of institutional teams. In addition, our workshop model follows the recommendation by D'Avanzo (8) that faculty be collaborators in curricular change and those of Khatri *et al.* (9) that curriculum developers interact directly and collaboratively with end users and adopters.

The goals of our two-and-a-half-day workshops were to introduce faculty participants to: 1) approaches to inquiry-based learning in laboratory courses and the efficacy of these approaches, 2) bean beetles as a model system for inquiry-based laboratory courses and how to use them in that context, 3) guided-inquiry methodology and its implementation in laboratory courses, and 4) assessment of student learning outcomes in laboratory courses. In addition, faculty pairs from a particular institution began developing a new laboratory module in their sub-disciplinary area of biology using bean beetles. To prepare participants for the workshops, we gave them several articles on inquiry-based learning in laboratory courses to read prior to the first full day of the workshop. In addition, they were asked to conduct a literature review on research with bean beetles in their sub-disciplinary area and add at least two research articles to an online bibliography on the bean beetle website. Finally, they were asked to familiarize themselves with the Institutional Review Board (IRB) process at their institution. The chronological structure of the workshops is outlined in Table I. We describe each session of the workshop in Appendix I, along with the demographics of workshop participants.

Does this workshop format lead to curricular change?

The responses of workshop participants to surveys immediately after each of the four workshops and then again at the end of the four-year project provide a snapshot of participant concerns and the likelihood that the workshops would foster meaningful change in learning and teaching. More direct measures of effectiveness are the implementation of newly developed laboratory activities, changes in instructional practices, continued work on guided inquiry, and dissemination of new laboratory activities.

Post-workshop survey. At the end of each of the four workshops, our external evaluator administered a workshop survey with the two-fold goal of determining whether changes to the workshop were needed in subsequent years and assessing the progress of participants in preparing new laboratory protocols (Table I). Although the intent of these surveys was formative evaluation, consistent positive responses to workshop components suggested the

importance of specific activities for faculty professional development workshops. The results of the post-workshop survey are described in Appendix 2.

Retrospective survey. Fifty-five (55) of our 82 workshop participants (67%) responded to a retrospective survey administered online by our external evaluator after the end of the project. The survey provided data on the impact of the workshops, participant perspectives on potential improvements to our workshop model, and the characteristics of successful faculty development workshops. Based on the retrospective survey, the majority of respondents agreed or strongly agreed that participation in our workshops increased their confidence in using student-centered, inquiry-based approaches (84%) and influenced their approach to teaching (78%) (Fig. 1). All but two respondents agreed to some degree that our workshops were “successful,” with 76% strongly agreeing.

In our workshops, we emphasized the use of undergraduate research students for the initial development of inquiry-based laboratory activities. Undergraduate research students may be engaged to pilot new ideas for laboratory courses, saving time and effort for faculty developing new laboratory activities. One advantage of this approach is that undergraduate student researchers will have similar questions and struggles to those of students who will use the

module in their laboratory course. Using this approach, faculty can troubleshoot a new laboratory module more thoroughly before implementing it in a course for the first time. Fifty-three (53) of 55 respondents involved undergraduate research students in their curriculum development efforts. Four of those respondents also involved graduate students in addition to undergraduate students. One respondent involved only graduate students.

The curriculum development efforts initiated at our workshops had carryover effects at some institutions. Eighteen (18) respondents indicated that the laboratory module that they developed was implemented in courses other than their own. At these institutions, a median of two additional courses were impacted with a range from one to four courses. In addition, 14 respondents indicated that faculty other than themselves and their workshop partner taught using the new bean beetle module. A median of two additional faculty (range: 1–5 faculty) were impacted at these institutions. Besides implementation in other courses and with other faculty, the workshops resulted in participants developing additional inquiry-based laboratory modules. Forty-two (42) out of 55 respondents (76%) indicated that they had developed additional inquiry-based modules. Although the majority of respondents had implemented their inquiry-based laboratory activity using bean beetles and had developed additional inquiry-based modules, seven

TABLE 1.
Workshop agenda with evaluation results pooled for all four workshops.

Agenda Items		Duration	Scale	<i>n</i>	Mean
Day 1	1. Introductions	1 h			
	2. Discussion of inquiry-based learning in laboratory classes	1 h 15 min			
			Informative	82	3.76
			Useful	82	3.79
			Engaging	82	3.67
	3. Developing inquiry-based labs and the role of the undergraduate research students	1 h			
			Informative	79	3.8
			Useful	79	3.75
			Engaging	79	3.73
	4. Lunch discussion in sub-disciplinary groups	1 h			
			Informative	17	3.12
			Useful	17	3.12
			Engaging	17	3.53
	5. Bean beetles as a model system 1	3 h			
			Informative	82	3.9
			Useful	82	3.96
			Engaging	82	3.9
	6. Bean beetles as a model system 2	2 h 15 min			
			Informative	63	3.76
			Useful	63	3.67
			Engaging	63	3.75

TABLE I.
Continued.

	Agenda Items	Duration	Scale	n	Mean
Day 2	7. Small-group brainstorming with partners	1 h	Informative	81	3.75
			Useful	81	3.81
			Engaging	81	3.85
	8. Introduction to student assessment	1 h 15 min	Informative	82	3.41
			Useful	82	3.38
			Engaging	82	3.24
	9. Lunch discussion in sub-disciplinary groups	1 h	Informative	16	3.13
			Useful	16	3.19
			Engaging	16	3.44
	10. Small-group brainstorming with participants from similar institution types	1 h	Informative	82	3.55
			Useful	82	3.51
			Engaging	82	3.66
	11. Small-group brainstorming with participants from different institution types	1 h	Informative	58	3.59
			Useful	58	3.5
			Engaging	58	3.66
	12. Presentation preparation with partners	45 min	Informative	80	3.51
			Useful	80	3.68
			Engaging	80	3.64
	13. Group presentations	2 h	Informative	81	3.88
			Useful	81	3.7
			Engaging	81	3.6

Responses used a four-point Likert scale (1 = not at all to 4 = to a great extent). Lunch discussions were added in the last year of the project. “Bean beetles as a model system 2” and “Small-group brainstorming with participants from different institution types” were added for the last three of the four workshops. See Appendix 3 for the complete workshop survey.

faculty responded to a prompt asking them, “What factors influenced your decision NOT to use inquiry-based learning in your class(es)?” Using qualitative content analysis (17), we defined common themes in these responses. The most common response (5 of 7 respondents) indicated lack of time or limited opportunity to develop and implement inquiry-based activities.

At the end of the Retrospective Survey, we asked faculty participants two additional open-ended questions. Faculty participants were asked to describe two or three ways that we could improve our workshop and follow-up assistance. Workshop participants indicated that a more intensive and systematic follow-up would have been helpful. Receiving more guidance from presenters with expertise and having more time to informally discuss new experimental protocol

ideas during the workshop also were suggested as potential improvements (Table 2). In addition, we asked participants to describe what, in their opinion, makes a faculty workshop successful. Workshop participants suggested that working in teams and collaborating with faculty from other institutions while working on hands-on activities was very useful. In addition, the development of practical ideas and products with the guidance and expertise of workshop presenters, and having the time to focus, brainstorm, and develop ideas also were helpful. The participants also noted that good organization and logistics contributed to the success of the workshops (Table 3).

Faculty instructional practices. Thirty-eight (38) participants completed an online survey on their instructional

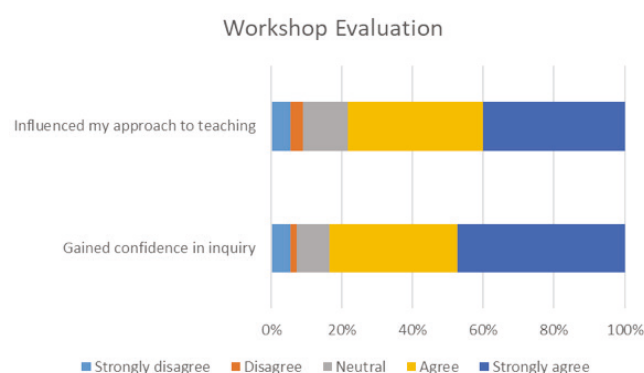


FIGURE 1. Participant perceptions of the impact of our workshops on their teaching based on a retrospective survey. Participants who responded to the survey ($N=55$) were from the range of institution types represented at our workshops (two-year colleges: 18%, liberal arts colleges: 38%, comprehensive and research universities: 22%, minority-serving institutions: 22%) with representation similar to participants in our workshops.

TABLE 2.

Participant perspectives on improving workshops and follow-up assistance.

Theme	Number of Responses	% of Responses
More intensive and systematic follow-up	7	33%
More guidance from individuals with expertise	6	29%
More time to informally discuss ideas	3	14%
Clearer communication on the expectations for deliverables	2	10%
Alerts when new materials posted to website	2	10%
More opportunities for collaboration among participants	1	5%

A total of 21 independent responses were received. We categorized the content of these responses, using qualitative content analysis.

practices in their laboratory course prior to the workshop and again after they implemented the new curriculum that they designed (18). Based on a related survey that we administered to students to address inquiry-based learning and assessment in undergraduate laboratory courses, we defined five constructs for instructional practices: metacognition, feedback and assessment, scientific synthesis, science process skills, and instructor-directed teaching (18). Changes in self-reports of faculty instructional practices suggest that participants significantly increased their emphasis on science process skills and scientific synthesis in their laboratory courses after the workshop (Fig. 2). In addition, they reported a marginally

TABLE 3.

Participant perspectives on what makes a faculty development workshop successful.

Theme	Number of Responses	% of Responses
Working in teams and collaborating with others	18	39
Practical ideas and products as outcomes	17	37
Guidance and expertise support from presenters	13	28
Hands-on activities	11	24
Good organization and logistics	8	17
Having time to focus, brainstorm, and develop ideas	7	15

A total of 46 independent responses were received. We categorized the content of these responses, using qualitative content analysis, and tabulated the most common responses. Some responses were categorized into more than one theme.

significant decrease in instructor-directed teaching (Fig. 2). Their instructional practices related to feedback and assessment and student metacognition did not change (Fig. 2), but our workshops did not strongly emphasize these aspects of inquiry-based teaching.

Implementation rate. In the year following each faculty development workshop, the members of each team were expected to fully develop and class-test a new laboratory protocol with bean beetles that they had begun developing at the workshop. These class-tested protocols were written in a prescribed format, were submitted to us for peer review, and were returned to participants for revision and editing prior to posting on the website. A total of 62.2% of the individual faculty participants completed this written submission outcome (51 of 82 participants) by the end of the project, representing 68.3% of the participant teams (28 of 41 teams). The individual and team rates were different because only one member of five of the faculty teams completed their work and authored the final class-tested protocol. The implementation rates varied with the institution type, ranging from 50% to 84.6% (Fig. 3A). The teams from all the different institution types were represented in each of the four workshop years. The completion rates by workshop year were similar, with the exception of 2010 (Fig. 3B). The completion rate was not influenced by the total elapsed time until the end of the project, since the last cohort had the greatest completion rate and the second cohort had the worst completion rate.

Dissemination by workshop participants. While the main goals of our workshops were to change the

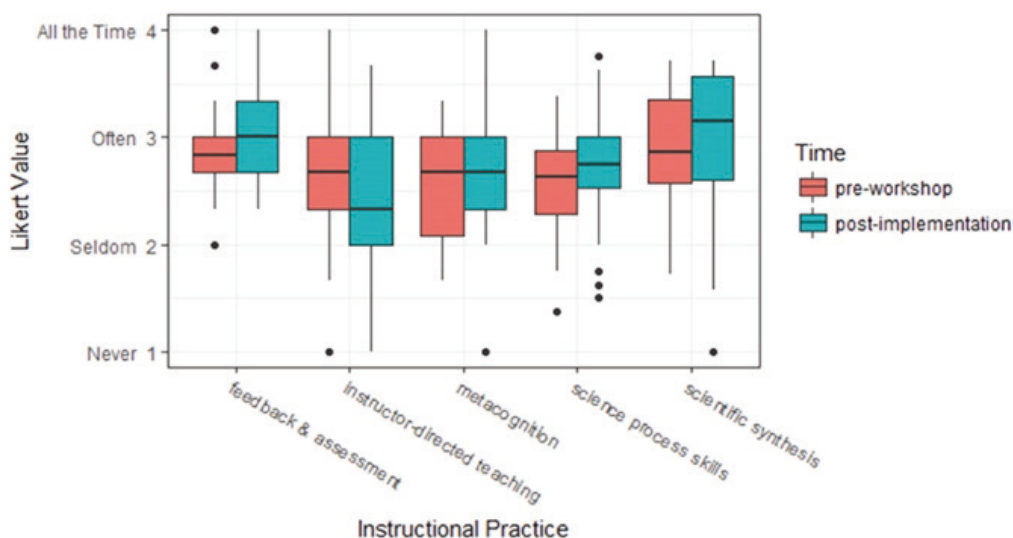


FIGURE 2. Faculty instructional practices prior to and following workshop participation and implementation of a new guided-inquiry laboratory activity. Instructional practices were determined using the survey and constructs in Beck and Blumer (18). Faculty ($N=38$) increased their emphasis on science process skills and scientific synthesis in their laboratory courses after the workshop (Wilcoxon signed rank tests: $Z=2.42$, $p=0.016$; $Z=2.29$, $p=0.022$, respectively). They also decreased their instructor-directed teaching to a marginally significant degree (Wilcoxon signed rank tests: $Z=1.75$, $p=0.08$).

faculty teaching practices in laboratory courses at their own institutions and have faculty develop new guided-inquiry modules, dissemination of their work through presentations and publications increases the impact of their efforts and further confirms the success of our workshop model. During the project (2009–2013), workshop participants made 12 presentations at regional and national meetings. In addition, they published four peer-reviewed papers (one in *Bioscience*, two in the *American Biology Teacher*, and one in the *Proceedings of the Association for Biology Laboratory Education*), and one abstract in a conference proceedings (*Proceedings of the Arizona-Nevada Academy of Science*). Subsequent to the completion of the project (2014–2018), an additional eight presentations were made at regional and national meetings, and another seven peer-reviewed papers were published in the *Proceedings of the Association for Biology Laboratory Education*. The majority of the presentations (45%) were at the Association for Biology Laboratory Education, which emphasizes hands-on workshops that foster dissemination. Other conferences included education-focused meetings (National Association of Biology Teachers and National Science Teachers Association), disciplinary society meetings (Animal Behavior Society, Society for Integrative and Comparative Biology, and Society for Neuroscience), and regional meetings (Georgia Academy of Science and Arizona-Nevada Academy of Science). A key strategy for developing new laboratory curricula that was introduced in our workshops was the use of undergraduate research students. Eight of the presentations by participants included undergraduate co-authors, including a presentation at the Community College Undergraduate Research Initiative (CCURI) annual meeting.

Recommendations

Based on the outcomes of our workshops and feedback from participants, we propose several recommendations for faculty professional development workshops on laboratory teaching and curriculum development. First, faculty should attend workshops in teams from their institutions. Partners may be more effective in trouble-shooting problems, identifying pitfalls, and developing creative solutions in the new curriculum, as well as implementing the new curriculum in multiple course settings. In addition, partners provide the personal support necessary for adult learners to implement new practices (8, 19) and collegial interactions that may be more effective in addressing departmental or institutional barriers to change (10). Second, workshops should allow participants to develop curricula that can be implemented with relatively little additional work after they return to their institutions. Time to develop new materials is often indicated as a barrier to implementing pedagogical innovation (7). Faculty see the value in practical outcomes and often do not have much additional time for further curriculum development once they return to their institutions. For some faculty, these practical outcomes might serve as the “reward” associated with participation in professional development (8). Third, workshops should allow faculty time to “work” on tangible products and should involve hands-on activities. These activities are important for adult learning (19, 20) and can serve to model the pedagogical approaches we aim to foster (8, 21). Fourth, the workshops should be of sufficient duration to allow for faculty to develop expertise and tangible products but short enough that they do not “burn out.” Based on our experience, approximately two and a half days provide sufficient time. This

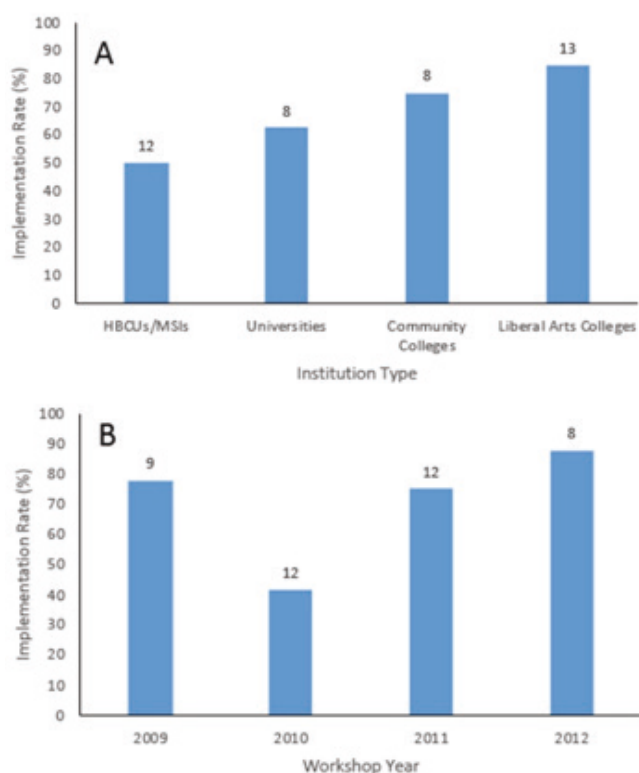


FIGURE 3. Implementation rates by institution type (A) and workshop year (B). Implementation rates varied by institution type (A) among HBCUs and MSIs, universities, community colleges, and liberal arts colleges (using non-overlapping categories in which “university” and “liberal-arts college” were neither “minority-serving” nor “community colleges”) with sample sizes (number of teams) shown above each bar. The teams from all the different institution types were represented in each of the four workshop years. The implementation rates by workshop year (B) were similar, with the exception of the workshop participants in 2010 (sample sizes, which are the number of teams, are given above each bar). HBCU = historically-black college or university; MSI = minority-serving institution.

time frame is similar to the three-day format of workshop conferences hosted by the Association for Biology Laboratory Education. In longer workshops, we perceive diminishing returns on faculty time. In addition, longer workshops might exclude faculty who are unable to be away from their jobs, their families, or other commitments for extended periods of time. Finally, a structure for ongoing and systematic follow-up with participants to provide feedback, encouragement, and support is essential (15).

SUPPLEMENTARY MATERIALS

- Appendix 1: Description of Workshop Activities
- Appendix 2: Post-Workshop Survey Instrument
- Appendix 3: Post-Workshop Survey Results
- Appendix 4: Faculty Retrospective Survey Instrument
- References for appendices

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