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Using Workshops to Improve Instruction in STEM Courses

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Abstract

Workshops are currently one of the most popular ways for instructors in STEM fields to learn more about teaching and learning. Yet research shows we often do not know what participants gain from attending. This article suggests ways of measuring impact of instructional improvement workshops that will help not only workshop providers with designing better workshops but also prospective participants with choosing workshops wisely.

Workshops are currently one of the most popular ways for instructors to learn more about teaching and learning. Yet we often do not know whether workshops can really improve instruction, partly because those who design and deliver instructional improvement workshops seldom find out what participants actually learned from the workshop and how they applied it. This lack of information about workshop impact makes it difficult for instructors and administrators to make informed decisions about whether workshops are a good use of time and money.

This article suggests that workshops can be a powerful way to help instructors improve their teaching, but we still need much better information about the short- and long-range impacts of workshops. First, we define what instructional improvement workshops are, why they are used, and what we know about their effectiveness. Second, we offer a model for planning and evaluating workshops that can make them more effective. Third, we use the case of an NSF-funded science instructional improvement workshop series to illustrate a six-component process for planning effective workshops and five levels of workshop impact. Finally, we suggest steps that instructors and administrators can take that will maximize workshop impact.

Defining Educational Workshops

Educational workshops are typically brief and intensive gatherings of relatively small groups of like-minded practitioners that focus on cultivating competence in particular areas of need. Because workshops aim to address "real-world issues" in a fairly short time, they are an attractive alternative to semester-long courses, which are usually more concerned with theoretical and conceptual knowledge. Consequently, educational workshops have become one of the most common ways of providing training and professional development in many professions.

To offer support to instructors—including those in science, technology, engineering, and mathematics (STEM) fields—instructional developers use workshops more

frequently than other "interventions" (e.g., individual consultations, publications). The workshop format is attractive because it can be adapted to address the needs of diverse audiences. Workshops can be marketed broadly or targeted to specific populations (e.g., teaching assistants, instructors of large lecture courses), and, depending on their aim, can vary in length from a ninety-minute, one-shot session to series that span an academic year. They may feature outside or "expert" presenters or provide local instructors with a forum to share what they know about effective instruction. Moreover, workshops are well-suited to helping instructors change their teaching practices for two reasons: they can bring together instructors who otherwise tend to teach in isolation and they can focus on changing individuals rather than organizations or groups. For these reasons, workshops tend to have greater influence on instructional practices—which are typically a prerogative of individual instructors—than on other aspects of faculty work that involve joint decision-making, such as curriculum.

How Can Workshops Promote Instructional Change?

The ultimate goal of instructional improvement workshops—whether for the sciences or other disciplines—is change in instructor behavior that improves the conditions for student learning. This goal is daunting: getting instructors to change their approaches to, and beliefs about, teaching is notoriously difficult.

How might instructional change occur? One well-known model of change (Schein 1992) applied to improving college teaching (Paulsen and Feldman 1995) entails a three-stage process: unfreezing, cognitive restructuring, and refreezing.

The first stage depends on challenging, or unfreezing, firmly held and often implicit assumptions about the effectiveness of one's behavior. When an individual realizes that her behavior does not correspond with her ideals and she feels sufficiently equipped to take a risk, she is more likely to attempt a new course of action. Helping instructors question unwarranted assumptions about their instructional effectiveness in ways that avoid making them feel defensive can motivate instructors to re-examine their teaching.

In the cognitive restructuring stage, the individual seeks to discover, explore, and try out alternate behaviors that she expects will better fit her self-image and serve her ideals. To discover ostensibly better ways of acting, she will to look to others—sometimes scanning her environment to gather as many options as possible and other times identifying a particular individual whom she seeks to emulate in some way. During this phase of experimenting with new and different approaches, it is crucial that the individual receives feedback that is helpful, ongoing, and, especially for instructors, credible.

The third stage, refreezing, often poses the greatest challenge to the change process. As the individual moves from incorporating new ways of acting into lower- and then increasingly higher-stakes practice settings, her ability to sustain and refine her new way of acting depends on (1) her ability to integrate this new activity with other practices and (2) receiving "re-confirmation" that this is an acceptable and appropriate

behavior. This refreezing stage poses the greatest challenge to an innovative practice because, even when practitioners know that their current methods are not working and discover other methods that might be more effective, they may be unable to (a) integrate the new practice with their own as well as others' well-established practices and (b) make sense of mixed and negative feedback. For example, instructors who attempt innovative teaching approaches often wonder whether to persist when students endorse the approaches and their colleagues do not (or vice versa).

Although workshops can activate and propel each of these stages of change, they tend to have more influence on the middle stage of cognitive restructuring, when exploration and experimentation are crucial for deciding what might work better, than on the first and third stages, which often occur outside the workshop timeframe. Since most instructional workshops are voluntary, they are more likely to attract instructors who already are aware that some aspect of their instruction is not working well; in other words, they already are in the unfreezing stage. Workshop impact tends to be weak for the third stage because much of the effort necessary to "refreeze" one's new beliefs and methods into habits of practice must occur after the workshop, when the individual applies what she learned to her real-life situation.

How Effective Are Instructional Improvement Workshops?

Their popularity notwithstanding, what do we know about the effectiveness of workshops in promoting and sustaining instructional improvement? Not enough. In their review of the research on the efficacy of various instructional interventions, Levinson-Rose and Menges (1981, 406) explained that "workshops and seminars are probably the most frequent but least evaluated." A review updated a decade later found much the same: that workshops were among the most common instructional interventions, yet evidence of their effectiveness was still largely non-existent. According to Weimer and Lenze's (1991) review, of the few studies that attempted to assess workshop effectiveness, most used measures of participant attitudes—such as participants' satisfaction with the workshop experience and their intentions to apply what they had learned—to gauge workshop success. Participant attitude data often indicate that instructors feel workshops are interesting and informative. However, this kind of data is the least convincing type of evidence of workshop impact because "it does not prove that the program caused them to change any of their instructional behaviors, nor does it establish any relationship between program participation and significantly improved learning outcomes" (Weimer and Lenze 1991, 304). In concluding their review of workshop-based interventions, the authors stressed their concern about the growing use of an approach to improving instruction that has so little evidence of effectiveness. Most recently, Sell (1998) reviewed twelve additional studies of workshops and related programs for STEM instructors published between 1988 and 1997. Although Sell noted some improvement in the scope and rigor of workshop studies, he observed that researchers and practitioners still lack convincing evidence that workshops actually promote instructional improvement, and, if they can, which kinds or features of workshops are most strongly correlated with this outcome. In

short, we lack important evidence that workshops, however popular and apparently promising, actually promote enduring instructional improvement.

Without evidence of effectiveness, clients of workshops—namely, instructors who attend them and administrators who fund them—cannot judge well whether, for example, one workshop is any better than another. However, if workshop clients began asking workshop organizers to provide data about the kinds of benefits that participants could reasonably expect, then it is more likely that organizers will begin to gather more credible evaluation data than simply whether participants "liked it." In turn, workshop organizers with hard data about effectiveness (e.g., learning gains) will gain a marketing advantage with academics.

The Power of Gathering Evidence of Workshop Impacts

Realizing the potential of instructional improvement workshops depends greatly, then, on getting better descriptions of the scope of workshop impacts and outcomes. What kinds of data can provide this evidence?

One well-known model for evaluating training programs (Kirkpatrick 1998) claims that a workshop's success can be based on four levels of evaluation: (1) participants' reaction to the workshop; (2) their learning; (3) changes in their behavior; and (4) results. For an evaluation of a large-scale instructional development project targeted to STEM graduates-through-faculty, Colbeck (2003) modified Kirkpatrick's four levels and added a fifth level—participation. Below are Colbeck's five levels of impact of training programs and the fundamental questions each level addresses:

Participation: Who attended?
Satisfaction: Were participants satisfied with the program? Did they get from the workshop what they expected?
Learning: What did participants learn? What attitudes or beliefs were acquired or changed? What skills were developed?
Application: Did participants apply and refine knowledge, attitudes, and skills in subsequent situations of authentic practice?
Overall Impact: What role, if any, did workshop participants subsequently play in improving the less-than-ideal situation or condition that the workshop originally intended to address?

Each level of impact is related to the preceding one, and the effort needed to gather convincing evidence increases with each level; that is, analyzing workshop attendance is significantly easier than determining how well participants applied what they learned at the workshop. This model for evaluating levels of impact shows that the kind of data workshop planners can obtain easily (such as participation data, and data on whether participants liked the workshop) is generally unable to provide evidence of what participants learned, whether they applied their learning in practice, and whether any application actually improved the given situation.

Designing an Evidence-Based Workshop

Workshop clients and planners ought to know what credible evidence of workshop effectiveness looks like. To this end, we refer in the following section to the workshop-based science instructional improvement project—the Regional Workshops Project (RWP)—(1) to describe good practices for planning effective workshops and (2) to demonstrate how various levels of workshop impact were evaluated. We are using the RWP as an example of planning evidence-based workshops because, as a project funded by the National Science Foundation (NSF), it was obliged to articulate most of these planning components in its initial proposal and because we served as its external evaluators.

In 2000, the NSF funded the Regional Workshops Project through its Course, Curriculum and Laboratory Improvement (CCLI) National Dissemination program. In the following five years, the RWP principal investigators, James Haynes and Michele Hluchy used fourteen five-day workshops to disseminate a national model for science education that melds classroom instruction, field and laboratory techniques, and cooperative learning that addresses real environmental problems in college communities (Haynes, Hluchy, and Connolly 2005). Because it uses environmental problem-solving as a theme, the Regional Workshops Project targets instructors who teach environmental studies courses, including chemists, biologists, geologists, geographers, engineers, and science educators. Among the instructional goals that guide the workshop curriculum and are used to evaluate the workshop's learning outcomes are (1) encouraging participants to revise or create units, courses, or programs that will focus on applied environmental problem-solving as a method to stimulate undergraduates' interest in the sciences and environmental issues in local communities and (2) introducing participants to innovative strategies and techniques currently used to address ecological and environmental issues.

Based on our experiences as evaluators of instructional improvement workshops and programs, we sometimes see instructors plan workshops that are driven not by decisions about what participants should learn by the end, but rather by what they believe "ought to be taught." In turn, their workshops employ "teaching-as-telling" instructional approaches that tend to emphasize content over application and limit opportunities for participants to learn from each other. These workshops typically beg the same question asked often of undergraduate courses: Are participants really learning what matters?

Like undergraduate instruction, workshop planning can often benefit from a little bit of "backward design" (Wiggins and McTighe 1998). That is, rather than structuring a learning experience around the content to be taught, effective workshops tend to begin with the end—learning outcomes—in mind. One straight-forward model for planning educational workshops (Sork 1984, 1997) does just that—it puts learning outcomes at its center and uses both formative and summative evaluation to determine whether those outcomes are being met and to what degree. Sork's model for workshop planning consists of six components: surveying the planning environment; justifying and

focusing the plan; clarifying intended outcomes; developing a summative evaluation plan; formulating a plan for instruction; and formulating a plan for workshop administration. Below, we describe these planning activities and how we used them in planning the Regional Workshops Project (RWP).

Surveying the Planning Environment

Workshop planners need to keep one eye always on the various milieu—e.g., national, institutional—in which the workshop is planned and implemented. In the Regional Workshops Project the principal investigators used their initial funding proposal to demonstrate familiarity with the national context for improving student learning in STEM courses. Incorporating local and institutional considerations into the workshop plan, however, was an ongoing task, in part because each of the fifteen workshop hosts was expected to provide field sites with real environmental problems (e.g., PCB contamination downstream from a local mill) where participants could practice instructional exercises.

Justifying and Focusing the Workshop

Planning entails managing the fit between what participants need and what the workshop can reasonably offer. Thus, one important activity is needs assessment—determining what participants need to know and do to address overarching aims, such as improving conditions for student learning. However, because prospective participants may have many unmet professional needs, it is especially important for planners to give the workshop a sharp focus and avoid a common temptation to address numerous issues all at once.

In the RWP, the principal investigators focused their attention on instructors who teach environmental studies courses, which usually employ multiple disciplinary perspectives, to address real-world issues. Haynes drew upon his previous experience with leading three-week workshops for environmental science instructors during the 1990s to conclude that workshop participants needed ideas for promoting problem-based learning in their courses and assistance with two tasks crucial to sustaining instructional innovations: (1) assessing student learning and (2) acquiring supplemental funding (e.g., for purchasing lab equipment, buying out released time). As a result of identifying needs that previous workshops had not addressed, Haynes and Hluchy successfully justified a new series of instructional-improvement workshops.

Clarifying Intended Outcomes

Planning requires defining what participants will learn from the workshop. Because workshops are typically concerned with modifying participants' behavior, "learning" consists of positively influencing what people understand (knowledge), what they believe (attitudes), and what they can do (skills). Thus, a good workshop plan will have a few, well-articulated learning outcomes that will drive both the workshop curriculum and the workshop evaluation. It is important to use formative feedback to determine whether the learning outcomes are achievable and appropriate. For example, in the initial RWP workshops, it proved difficult to pack all of the workshop content and activities into four and a half days. Formative feedback clarified that participants

valued one of the five intended outcomes—using models and concepts from organization development theory to support participants' instructional modifications—less than the others. In response, the organizers improved workshop outcomes overall by reducing the amount of time devoted to the least-valued outcome.

Developing a Comprehensive Evaluation Plan

A well-designed workshop includes, early on, a comprehensive evaluation plan, which incorporates formative evaluation and a summative evaluation. Formative evaluation occurs while a program is underway and provides planners with ongoing feedback that may be used to modify the program. Summative evaluation, in contrast, is conducted after a program or activity has concluded; its purpose is to provide stakeholders with evidence-based judgments about a program's overall worth or merit. Although many workshop planners treat summative evaluation as an afterthought, the most effective workshop planners develop a summative evaluation plan very early in the workshop planning process.

When the NSF reviewed the RWP proposal, a program officer explained to Haynes and Hluchy that their proposed evaluation plan was inadequate and that their funding was contingent on developing a more robust and credible evaluation plan. They, in turn, contacted us at the University of Wisconsin, and the formative and summative evaluation plan we proposed was funded through a supplemental grant. Subsequently, we became valued members of the workshop planning team, attending every workshop to oversee data collection and to help the leaders use daily feedback to make mid-course corrections when necessary. Our comprehensive evaluation design has drawn upon five key sources of participant data: a pre-workshop questionnaire, daily formative feedback forms, an end-of-workshop focus group, an end-of-workshop questionnaire, and a follow-up questionnaire administered approximately one year after the workshop.

Formulating Plans for Workshop Administration

Implementing an effective workshop includes marketing to prospective participants, managing finances, and scheduling a meeting location. A well-designed workshop will identify and sequence all of the activities that must be completed before, during, and following the workshop. Planning these tasks is even more important for longer workshops, which may include lodging, meals, travel, and an application process. As the RWP principal investigator, Haynes was responsible for all aspects of workshop administration, including providing the funding agency with annual updates. In addition, Haynes convened a group of workshop "hosts" each fall and offered them a detailed and regularly updated list of tasks that needed to be completed before, during, and after the workshop.

Formulating Plans for Workshop Instruction and Learning

This final component consists of planning the "guts" of the workshop—the activities that will help participants achieve the desired learning outcomes and encourage their application beyond the workshop. To achieve a workshop's learning outcomes, planning the learning-and-teaching activities includes, but is not limited to, these

considerations: content, sequence, duration, pace, personnel, instructional approach (e.g., small group work, interactive presentation), setting, and variety.

The RWP curriculum was a combination of interactive presentations and small-group work in computer labs and in field settings. Because the four and a half days of the workshop were so packed with scheduled activities (typically eight a.m. to eight p.m.), transmitting workshop content as efficiently as possible meant that workshop presenters did not always model the methods they were trying to encourage, which sometimes frustrated participants.

Examples of Evidence Supporting Various Levels of Workshop Impact

As mentioned earlier, one way to gauge the extent of a workshop's success is by looking at five levels of impact. Here, we review five levels of evidence, four of which are illustrated by examples from the RWP.

Evidence of Participation

This level of impact focuses on who attended and the groups or organizations they represent. Evidence of workshop impact at this level can include data about the number of participants, the units or organizations they represent, and their demographic profiles. For example, pre-workshop questionnaires sent to RWP participants revealed that, of the thirty-eight participants who attended the two 2002 workshops, eleven were from two-year colleges, twenty-one were women, fifteen were associate professors, and twenty-eight had earned a PhD.

Evidence of Satisfaction

The next level of workshop impact is based upon participants' satisfaction with the workshop: Did they value their workshop experience? Useful satisfaction data come not only from questions about their overall experience but also from items asking about specific features or parts of the workshop (e.g., materials provided, interactions with other participants, presentations). Because satisfaction often stems from having one's expectations met, it is helpful to know why participants wanted to attend and what they expected to gain. Satisfaction data are typically gathered at the end of the workshop and are among the most commonly collected evaluation data.

At the Regional Workshops, we monitored participants' satisfaction by administering and reviewing brief feedback forms each night. Across workshops, the daily data gave us a good idea which parts of the workshop tended to please or frustrate participants. An end-of-workshop survey provided comprehensive feedback on the workshop as a whole, asking, for example, "Overall, what is your reaction to this workshop?" with a scale of 1 to 5, where 1 was "very negative" and 5 was "very positive." Of 199 respondents across eleven workshops, the mean for this item was 4.69 (sd = 0.49). This measure provided workshop leaders with an important indicator of participants' satisfaction with the entire workshop experience that could be compared across all workshops.

Evidence of Learning

This level of impact measures what participants learn from the workshop—that is, what they "take away" to use elsewhere. This includes new knowledge, different attitudes and new skills. For example, creating learner-centered classrooms may require not only knowing some learning theory and using effective questioning techniques, but also examining one's beliefs about the instructor's role and the students' role in the learning process. Evidence of learning is most convincing when it examines all three of these dimensions of learning (knowledge, skills, and attitudes) and includes more than self-reported data. Andrews (1997), Guskey (2000), and Kirkpatrick (1998) provide good suggestions for how to gather these kinds of data.

One key intended outcome of the RWP was participants' learning more about innovative approaches to assessing student learning. Workshop curriculum provided an interactive session on assessment theory and principles and brought participants into a computer lab where they learned about the Student Assessment of Learning Gains, or SALG (Seymour et al. 2000). After the SALG tool was demonstrated and explained, participants were given time to explore the SALG on their own.

Among the kinds of evidence we collected to indicate whether participants learned about innovative ways to assess student learning, the end-of-workshop questionnaire asked (1) "To what extent do you currently feel knowledgeable about principles of assessing student learning?" and (2) "To what extent did this workshop contribute to what you now know [about this topic]?" with responses of "little or none," "some," and "highly." As one example, respondents who attended a 2005 workshop said that the workshop had more influence on their knowledge of assessment principles than on any other workshop topic. These scaled items were accompanied by an open-ended question, "What are the three most important things, if any, you learned from this workshop?" The most frequent response (sixteen of twenty-one participants) was assessment tools. These, with many other items, provided important data about how much workshop participants believed they learned about key topics and activities.

Evidence of Application

Gathering evidence of participants' ability to apply what they learned at a workshop to situations of actual practice is difficult and, therefore, infrequent, primarily because it requires following up with participants when enough time has elapsed to try out their learning. Again, asking participants to self-assess how successfully they are applying what they learned at the workshop can be very informative, but it faces the same limitations as other indirect, or self-reported, learning outcomes. For example, a participant may claim that she is now using methods that are more student-centered, but to outside observers and to the students themselves, the methods may still be teacher-centered. Methods for collecting convincing data about effective application may include interviews with participants as well as with those they work with (e.g. students, colleagues) and/or direct observation by assessors/evaluators would also provide important evidence of application. However, since interviews and site visits may be prohibitively costly in terms of money and time, workshop planners may need to settle for indirect methods, such as questionnaires, to assess application of workshop materials.

In the case of the RWP, we obtained another NSF grant that enabled us to gather evidence of application by following up with participants at least one year after their workshop and, in the case of the earliest cohort, also three years later. Here are two examples of how we used follow-up questionnaires to make qualified inferences about participants' application of RWP ideas and materials.

In the first example, we investigated the proportion of participants who, one year after their workshop, said they had added workshop activities to their classes. Of 109 participants in eight workshops (2002-2004) who responded to the question, "Of the following instructional activities featured at your Regional Workshop, which, if any, did you use in your target course?" twenty-nine said they added the Student Assessment of Learning Gains, twenty-four said they added a Stressed Steam Analysis exercise, and twenty said they added an Environmental Impact Statement assignment. In all, eighty-nine participants said they use one or more workshop resources to change their target course; twenty participants indicated they made no changes of any kind.

Our second example reveals factors that appear to have influenced participants' capacity for making workshop-related changes to their target course. We had hypothesized that most participants who attempted to implement workshop ideas would encounter various obstacles and impediments. In the pre-workshop questionnaire, we asked participants to rank challenges that they expected to encounter when changing their target course. Among 164 respondents from nine workshops (2003-2005), the concerns they most frequently identified as "great" were (1) making sure scientific content is covered and (2) balancing teaching with other professional/personal activities. When asked in year-after questionnaires to report which factors most affected their ability to modify their teaching practices, their answers were unchanged; as they had predicted, covering course content and balancing professional demands had complicated their instructional changes. From these data, we learned about factors that tended to frustrate participants' efforts to improve their instruction and also learned that participants had a pretty good idea of the struggles associated with the "refreezing" stage even before attending the workshop.

Evidence of Overall Impact

As some have pointed out (Andrews 1997; Kirkpatrick 1998; Sork 1997), the most difficult evidence to gather indicates whether the workshop had an appreciable impact on some state or condition that the workshop originally intended to address (e.g., improving the quality of undergraduate student learning in STEM courses). One can appreciate the challenge, then, of establishing a credible relationship between participating in a particular kind of workshop and subsequent improvements in the learning of participants' students. However, in a related NSF-funded study, colleagues from the University of Rochester are attempting to do just that (Cassata, Himangshu, and Iuli 2004). They are exploring the relationship between the Regional Workshops curriculum and improvements in student learning in participants' classrooms. In addition to using data collected as part of the RWP evaluation, these researchers are visiting the classrooms of a sample of RWP participants and using concept maps and a standardized instrument to discern whether participant implementation of workshop

methods and ideas enhances how and what students are learning. Although the work necessary to make a connection between an instructional improvement workshop and changes in student learning is sometimes daunting and often costly, it is an important aim that, ideally, every workshop evaluation should keep in sight.

Maximizing the Impact of Instructional Improvement Workshops

To maximize the impact of instructional improvement workshops, the first step is to choose well. Although some workshops are announced with eye-catching brochures, prospective participants can ask a few questions that help them judge the quality of the workshop beyond the quality of the brochure. For example, does the workshop clearly articulate what participants ought to learn? Does it offer opportunities for participants to practice the skills they are expected to perform after the workshop back on campus? Will participants receive high quality supplemental materials that actually will be useful and can be shared easily with colleagues? Does the workshop provide, or point participants to, resources that will help them persist with instructional innovations beyond the workshop? Are evaluation data from previous offerings of this workshop used to publicize the workshop? Prospective participants should not be reluctant to contact workshop planners directly for answers to these and any other questions they have.

Another important step to getting the most from a workshop entails supporting participants when they return to campus with translating concepts into practice. As the Schein (1992) change model suggests, workshops, although good at inducing cognitive restructuring, are less effective at furthering the refreezing process. The hefty workshop binders that sit on our shelves unopened are proof that what we learn at workshops often does not translate into practice. Thus, getting maximum value from a workshop significantly depends on helping participants with sharing what they learned with colleagues and with taking manageable steps toward change. For example, chairs and program heads who release funds for professional development can establish a norm that workshop participants discuss with at least one colleague how they plan to use what they learned. Thus, for administrators and instructors who want to maximize the impact of instructional improvement workshops, the biggest payoff may come from what costs nearly nothing: giving prospective participants a clear indication that they will be listened to and given some small measure of support and encouragement when they return to campus.

Conclusion

A workshop is not an end in itself but rather a means of helping instructors change and improve. Yet if instructors do not change as a result of their attendance, then it is difficult to justify the expense of time and money. We know intuitively that workshops, when run well, have the potential to give faculty not only tremendous motivation to change but also the means for doing so. However, not until we have better data about whether workshops are effective, and for whom and under what conditions, will their potential for instructional transformation be realized.

References

Andrews, G. J. 1997. Workshop evaluation: Old myths and new wisdom. In *New perspectives on designing and implementing effective workshops*, ed. Jean Anderson Fleming, 71-85. San Francisco: Jossey-Bass.

Cassata, A. E., S. Himangshu, and R. J. Iuli. 2004. What do you know? Assessing change in student conceptual understanding in science. Paper presented at the First International Conference on Concept Mapping, Pamplona, Spain, September.

Colbeck, C. 2003. Measures of success: An evaluator's perspective. Presentation made at forum at the Center for the Integration of Research, Teaching, and Learning, Madison, Wisconsin, October.

Guskey, T. R. 2000. *Evaluating professional development.* Thousand Oaks, CA: Corwin.

Haynes, J. B., M. Hluchy, and M. R. Connolly. 2005. Disseminating successful undergraduate science curriculum adaptation and implementation strategies and CCLI grant-writing techniques: Regional workshops led by successful innovators and experienced investigators, evaluating faculty changes processes, and assessing student understanding of STEM concepts. Paper originally presented at the proceedings of an April 2004 conference co-sponsored by the National Science Foundation (NSF) Division of Undergraduate Education (DUE) and the American Association for the Advancement of Science (AAAS) Directorate for Education and Human Resources Programs (EHR), Washington, DC.

Hilsen, L. R., and E. C. Wadsworth. 2002. Staging successful workshops. In *A guide to faculty development: Practical advice, examples, and resources*, ed. K. H. Gillespie. Bolton, MA: Anker.

Kirkpatrick, D. L. 1998. *Evaluating training programs: The four levels*, 2nd ed. San Francisco: Berrett-Koehler.

Levinson-Rose, J., and R. J. Menges. 1981. Improving college teaching: A critical review of research. *Review of Educational Research* 51 (1981): 403-34.

Paulsen, M. B., and K. A. Feldman. 1995. *Taking teaching seriously: Meeting the challenge of instructional improvement*, ASHE-Eric Higher Education Report No. 2. Washington, DC: George Washington University, Graduate School of Education and Human Development.

Schein, E. H. 1992. *Organizational culture and leadership*, 2nd ed. San Francisco: Jossey-Bass.

Sell, G. R. 1998. *A review of research-based literature pertinent to an evaluation of workshop programs and related professional development activities for undergraduate faculty in the sciences, mathematics, and engineering.* Cedar Falls, IA: University of Northern Iowa.

Seymour, E., D. J. Wiese, A. Hunter, and S. M. Daffinrud. 2000. Creating a better mousetrap: On-Line assessment of their learning gains. Paper presented at the National Meetings of the American Chemical Society, San Francisco.

Sork, T. J. 1997. Motivation with a mission: Understanding motivation and culture in workshop design. In *New perspectives on designing and implementing effective workshops*, ed. J. A. Fleming, 19-31. San Francisco: Jossey-Bass.

Sork, T. J., ed. 1984. *Designing and implementing effective workshops*, New Directions for Adult and Continuing Education, no. 22. San Francisco: Jossey-Bass.

Weimer, M. and L.F. Lenze, 1991. Instructional interventions: A review of the literature on efforts to improve instruction. In *Higher education: Handbook of theory and research*, ed. J. C. Smart, 294-333. New York: Agathon.

Wiggins, G. P., and J. McTighe. 1998. *Understanding by design.* Alexandria, VA: Association for Supervision and Curriculum Development.

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