ENGINEERING INSTRUCTIONAL DEVELOPMENT: PROGRAMS, BEST PRACTICES, AND RECOMMENDATIONS*

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ABSTRACT

Background

Economic globalization, rapid advances in technology and cognitive science, and a worldwide movement toward outcomes-based program accreditation increasingly require changes in the traditional model of engineering education design and delivery. As yet, no validated framework exists for designing instructional development programs that would equip engineering educators to make those changes. Existing programs consequently vary considerably in scope and effectiveness across countries and institutions.

Purpose

The goals of this article are to review the content and structures of instructional development programs around the world and to formulate a robust framework for designing and delivering effective programs for engineering educators.

Scope/Method

Literature on the design, implementation, and evaluation of instructional development programs is reviewed and summarized. Five criteria drawn from Raymond Wlodkowski's theory of adult learner motivation [expertise of instructors, relevance of content, choice in application, praxis (action plus reflection), and groupwork] were proposed as a framework for designing engineering instructional development programs, and the framework was applied to formulate recommendations for making programs effective. Research questions that should be explored to validate the framework were suggested.

Conclusion

Wlodkowski's five-factor theory of adult learner motivation provides a good framework for the design of engineering instructional development programs. The criteria are compatible with the cognitive science-based *How People Learn* instructional model and also with recommendations of faculty development authorities. Making engineering instructional development effective at an institution will require applying the criteria to program design and delivery and creating an institutional expectation of faculty participation in the programs.

Keywords: instructional development, faculty development, staff development

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INTRODUCTION

University Faculties: Unprepared Practitioners of a Highly Skilled Profession

*University** *faculty** members face a broad range of challenges over the course of their careers. Laursen and Rocque (2009) identify career stages at which they need to acquire different skill sets to meet those challenges: *early career* (teaching, advising, research, negotiation, and time management skills); *mid-career* (leadership and administration, collaboration, and outreach skills), and *later career* (the skill to identify and evaluate possible changes in career direction).

For which of those challenges are new and experienced faculty members systematically prepared? Throughout most of the history of higher education, the answer has been "none." In the past half-century, *faculty development** programs have become available on many campuses, but unfortunately many faculty members are still expected to learn how to do everything their job requires by trial and error. While there is much to be said for experiential learning, it is not terribly efficient. Studies by Boice (2000) show that for 95% of new faculty members it takes four to five years of trial and error to become fully productive in research and effective in teaching—and in teaching, the ones making the errors (the instructors) are not the ones paying for them (their students). Boice also found, however, that the other 5%—the "quick starters"—are effective in their first 1–2 years, and the actions that distinguish quick starters from their colleagues can be identified and taught. That is to say, a good faculty development program can cut several years off the normal faculty learning curve.

Given that finding, why is it not routine for engineering faculty members to participate in faculty development programs and for their administrators to encourage them to do it? The answer depends on which developmental areas are being discussed. Possible areas for faculty development include teaching, disciplinary research, educational research, learning the institutional culture, administration at the department and *college** levels, and changing activities and priorities at the mid- and late-career levels. For all of these areas but teaching, most faculty members do not participate in development programs because programs in those areas do not exist at their institutions.

On the other hand, faculty development programs that focus on improving teaching and learning (*instructional development** programs) can be found at many universities, but participation of faculty members in them is often low except in countries where it is mandatory (Groccia, 2010, p. 13), and many who do attend discount the relevance of the programs to them—sometimes unfairly, sometimes not. There are several reasons for this state of affairs. One is that many faculty members whose students perform inadequately do not acknowledge that the quality of their teaching may have anything to do with it. If their students get mediocre *grades** and/or give them low ratings, they argue that the students are incompetent or unmotivated, or that as instructors they maintain rigorous standards and high ratings only go to easy graders. Also, many instructors are unaware that alternatives exist to the traditional lecture-based approach with which they were taught. As long as they believe they are teaching appropriately and poor student performance and low ratings only reflect deficiencies in the students, they have no incentive to get involved in instructional development.

Exacerbating the problem in engineering is that instructional development on most campuses is commonly provided by social scientists (generally education and psychology faculty members) to campus-wide audiences. In the absence of discipline-specific examples it is easy for engineers to dismiss program content as irrelevant to their *courses**, subjects, students, and problems. Programs given specifically to engineering faculty members by teaching experts with engineering backgrounds are more

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* A number of common terms, such as *university* and *faculty* and *faculty development* and *instructional development*, mean different things in different countries. We will follow common United States usage in this paper. A glossary at the end of the paper shows alternative definitions of these terms, and we will insert an asterisk after each term the first time it appears to call the reader's attention to its presence in the glossary.

likely to attract and influence larger audiences, but they require an investment that engineering administrators and campus centers may be unwilling or unable to make. In short, there is generally neither a meaningful incentive for engineering faculty members to participate in instructional development nor a meaningful reward for any improvements in teaching that may result from their participation.

The Case for Faculty Development in Engineering

Providing faculty development in engineering has always been a good idea, but the need for it has taken on new urgency in the past two decades (Adams & Felder, 2008). Here are some of the driving forces:

- *Outcomes-based program accreditation.* A large and growing number of engineering schools have adopted outcomes-based accreditation, including schools in the United States (ABET, website) and countries that are participants in the Bologna Process (2010) and the Washington Accord (International Engineering Alliance, 2009). Equipping engineering students with the skills for specified outcomes such as effective communication and teamwork requires teaching and assessment methods not traditionally found in engineering education and unfamiliar to most engineering educators (Felder & Brent, 2003).

- *Anticipated shortfalls in engineering graduation rates.* In many countries in the world, graduation rates in engineering fall well below anticipated demands for new engineers, for reasons having to do with both recruitment and retention (Jain *et al.*, 2009). A common myth among engineering faculties is that engineering dropouts are the weakest students, but research has shown that the academic profile of those leaving engineering in the U.S. is indistinguishable from that of those staying, and many well-qualified students leave because they are dissatisfied with the quality of the teaching they have experienced (Seymour and Hewitt, 1997; ASEE, 2009). High-quality teaching is essential to retain qualified engineering students in the numbers required to meet current and future needs for engineers.

- *Changing engineering student demographics.* For most of the 20^{th} century, students entering engineering school tended to come from the top echelon of their countries' secondary school graduates. They were capable of learning even if they were taught using ineffective instructional methods. More recently, engineering schools have been admitting a much broader cross section of the student population, many of whom have the potential to be excellent engineers but who have to overcome deficiencies in their pre-college preparation. This is a positive development, but it means that ineffective teaching is no longer acceptable.

- *Changing engineering student attributes.* Today's college students—the much written-about "Millennials"—tend to have certain characteristics that pose challenges to their instructors (Wilson & Gerber, 2008). They are idealistic and self-confident, and they gravitate to curricula and careers in which what they do can make a difference to society. They are used to getting information in short visual bursts, and so they have less patience for lectures and textbooks than their counterparts in previous generations did. It has always been a mistake for faculty members to assume that the instructional methods that worked for them should work just as well for their students, but that assumption may be particularly bad when applied to the Millennials.

- *Changes in engineering practice in developed countries.* Many professional tasks for which the traditional engineering curriculum equips students are increasingly performed by technicians on computers or by workers in developing countries where those jobs have migrated. Different skills, such as innovative, multidisciplinary, and entrepreneurial thinking, as well as the ability to work with people from different countries and cultures who speak different languages, will be needed by engineering graduates in the decades to come (Friedman, 2006; National Academy of Engineering, 2004). Most engineering faculty members were never trained in those skills, but they will nevertheless need to help their students develop them.

- *Advances in instructional technology.* Teaching can be significantly enhanced by the full power of modern instructional technology, using such applications as interactive multimedia-based tutorials, system simulations, computer-aided design tools, course management software, personal response systems ("clickers"), and on-line communication tools. For engineering schools to continue to attract qualified applicants in an increasingly competitive market, faculty members must learn how to use the tools effectively, and their knowledge will have to be regularly updated.

- *Advances in cognitive science.* Thanks to modern cognitive science and a growing body of educational research (see next bullet), we know a lot about how people learn, the instructional conditions that facilitate learning, and the conditions that hinder it (Adams, 2011; Ambrose *et al.*, 2010; Baars & Gage, 2007; Bransford *et al.*, 2000; Fink, 2003; Heywood, 2005; Litzinger *et al.*, 2011; Olds & Johri, 2011; Svinicki & McKeachie, 2009; Wankat, 2002; Weimer, 2010). Summarizing the research and demonstrating its applications to teaching is a vital function of campus faculty development programs.

- *The scholarship of teaching and learning movement.* In the past two decades in the United States there have been growing incentives for engineering faculty members to engage in the scholarship of teaching and learning (Borrego & Bernhard, 2011; Case & Light, 2011; Jesiek *et al.*, 2009; Streveler & Smith, 2006). Not least of these incentives has been the National Science Foundation's major funding for educational research and its requirement that proposals for CAREER Awards and conventional disciplinary research grants must include educational components (National Science Foundation, 2010). Educational research methods are in many ways different from the research methods engineers are accustomed to, and engineering faculty members who receive training in those methods will be better prepared to conduct classroom research and to secure research funding (Borrego and Bernhard, 2011).

For all these reasons, engineering schools in the future will feel mounting pressure to provide faculty development. Doing so will help them make their faculties more effective in teaching and more competitive for research grants; equip their students with the skills they will need to succeed in an increasingly globalized world; and enable them to compete successfully with other engineering schools for the growing number of students seeking degrees through distance education.

Focus, Intended Audience, and Structure

This article reviews practices in the design, delivery, and evaluation of engineering instructional development programs (i.e., programs designed to help engineering instructors improve their teaching and their students' learning) and offers recommendations for making such programs effective. It touches only briefly on other aspects of engineering faculty development such as improving faculty members' research and administrative skills and promoting their personal development, and improving courses, curricula, and organizational policies.

The emphasis of the article is on practical aspects of engineering instructional development rather than comprehensive faculty development or instructional development theory. The intended audience is faculty developers and teaching leaders who wish to effectively address the instructional development needs of engineering faculty, and engineering administrators who wish to understand those needs and build and nurture programs that address them. Readers interested in a conceptual framework for comprehensive faculty development program design and evaluation should consult Taylor and Colet (2010), who formulated such a model based on a comparative analysis of programs in Canada and four European countries. Scholars seeking information on the philosophy, theories, and political and social contexts of faculty development can find such information in the edited volumes of Eggins and Macdonald (2003) and Kahn and Baume (2003, 2004).

The structure of the article is as follows:

- Options are presented for the *content* of instructional development programs that target new, experienced, and future faculty members, followed by discussion of whether programs should focus on pedagogical strategies, learning theories, or human development issues.
- Possible program *structures* are then defined—workshops, courses, and seminar series; consulting, mentoring, and partnering arrangements; learning communities; and teaching certification programs for faculty members and *graduate students*[*]. Pros and cons of campus-wide vs. discipline-specific programs, external vs. local program facilitators, and mandatory vs. voluntary participation are outlined.
- Strategies for assessing and evaluating instructional development programs are surveyed.
- A research-based framework for engineering instructional program design is formulated, and recommendations based on the framework are offered for developing and strengthening programs. Finally, questions for further study are suggested.

INSTRUCTIONAL DEVELOPMENT PROGRAM CONTENT

In this section we review some of the topics that might profitably be covered in engineering instructional development programs. Just as with teaching at any level, the choice of content should be preceded by the definition of program learning objectives, and the content should then be selected to address the objectives.

Programs for Current Faculty Members

Table 1 lists the most common teaching responsibilities of faculty members and possible instructional development program content appropriate for each responsibility. Instructional development programs normally cover subsets of the topics shown in Table 1. The material may be presented in a concentrated workshop that lasts for one or more days, a series of seminars over the course of a semester, a summer institute, or a course for which academic credit is given.

Two topics in Table 1—cooperative learning and problem-based learning—are marked as particularly suitable for more experienced faculty members. Those methods commonly evoke strong student resistance and interpersonal conflicts among students; before undertaking them, new faculty members are advised to gain experience and skill in more basic teaching methods. This does not mean that new faculty members should never attempt cooperative or problem-based learning, but if they decide to use those methods they should do so with open eyes and good preliminary training.

In some countries such as Denmark, Norway, Sweden, and the United Kingdom, and at many individual institutions in other countries, new faculty members are required to participate in extensive instructional development programs to qualify for *tenure*[*] and promotion (Schaefer & Utschig, 2008; Utschig & Schaefer, 2008). A more common practice in most parts of the world is to offer an optional new faculty orientation workshop that lasts between a day and a week. Brent *et al.* (2006) describe an orientation workshop for STEM (science, technology, engineering, and mathematics) faculty members that covers most of the topics listed in Table 1 as well as topics related to research and balancing professional responsibilities.

Category	Topics for Instructional Development Programs
General	Success strategies for new faculty members (Boice, 2000)[a] Cognitive science and modern theories of learning and teaching Theories of personal development[b]
Course design	Outcomes-based education and ABET Writing and using learning objectives Taxonomies of objectives Constructing syllabi and defining course policies Getting a course off to a good start Making new course preparations manageable
Course instruction	Motivating and engaging students Effective lecturing and active learning Using instructional technology effectively Cooperative (team-based) learning[b] Inductive methods (inquiry, project-based and problem-based[b] learning)
Assessing learning	Basic concepts of assessment and evaluation Assessing quantitative skills, conceptual understanding, and professional skills (written and oral communication, critical and creative thinking, ethical awareness, etc.) Formative assessment: classroom assessment techniques Marking assignments and examinations and grading courses
Troubleshooting problems	Classroom management Preventing, detecting, and dealing with academic misconduct Dealing with students' personal problems
Student diversity	Learning and teaching styles Approaches to learning (deep, surface, strategic) Levels of intellectual development Gender, racial, & ethnic diversity
Distance education	Techniques and challenges Engaging students interactively on-line
[a]Primarily for new faculty members [b]Primarily for experienced faculty members	

Table 1. Possible content of engineering instructional development programs

If experienced program participants have previously been through the basic material in a workshop, brief reviews of that material might be provided in advanced programs and more emphasis can be placed on strategies such as cooperative and problem-based learning, modern cognitive science and learning theories, and human development. Romano *et al.* (2004) describe an instructional development program for tenured faculty members. The program introduced participants to effective pedagogical strategies; supported them as they applied those strategies; gave them an opportunity to share ideas and experiences with peers; and provided a forum for them to discuss events that had an impact on their personal and professional lives. Another program designed specifically to address the developmental needs of mid-career faculty members is described by Baldwin *et al.* (2008).

Programs for Future Faculty Members

Before they seek their first academic position, postdoctoral fellows and graduate students can benefit greatly from training on how to get a good faculty position and what they will need to know in their first one to two years. The training may culminate with some form of certification. Table 2 lists possible teaching-related elements of such programs.

Workshops and seminars
• How students learn • Learning styles and teaching styles • Effective lecturing and active learning • Grading tests, assignments, and project reports • Facilitating process and computer laboratories • Tutoring in office hours • Preventing, detecting and dealing with academic misconduct • Dealing with student problems and problem students • Designing and planning new courses • Designing effective tests • Using instructional technology effectively • Applying and interviewing for a faculty position • Success strategies for new faculty members
Preparing the Professoriate programs
• Workshops and seminars • Readings and discussions • Class observations • Co-teaching with a mentor • Supervised teaching • Classroom research • Teaching portfolio development • Certification

Table 2. Possible content of future faculty instructional development programs

Specific models and recommendations for future faculty programs are given by Pruitt-Logan *et al.* (2002), Colbeck *et al.* (2008), and in other resources developed by the *Preparing Future Faculty* program (PFF, 2010) and the *Center for Integration of Research on Teaching and Learning* (CIRTL, 2010). Brent and Felder (2008) describe a graduate student training program that includes many of the elements shown in Table 2.

Critical Choices Regarding Program Content

Two important questions exist regarding the content of instructional development programs. First, should the main focus of the programs be pedagogical techniques and best practices, or fundamentals of how learning occurs (cognitive science), or explorations of the participants' personal experiences and their intellectual, emotional, and perhaps spiritual growth? Second, if a development program includes elements in all three categories, what is the optimal order of presenting them: cognitive and human development theories first followed by techniques and best practices (deductive presentation), or techniques and best practices first followed by interpretation in the light of theory (inductive presentation)?

Pedagogical practice vs. learning theory vs. human development. Many faculty development experts caution against an overemphasis on teaching strategies. Susan Ambrose (2009), a prominent faculty development authority who has worked extensively with engineers, observes, "*Too many programs dispense tips and strategies, as opposed to educating faculty members about how learning works…and we do a great disservice when we do this because tips and strategies often do not transfer* *across contexts. The mission of all of these programs should be to try and bridge the gap between what we know about learning and how we design and teach courses*." Ambrose and her colleagues provide a framework for that mission in the last chapter of *How Learning Works* (Ambrose *et al.*, 2010).

In her preface to *Inspiring College Teaching*, Maryellen Weimer (2010, p. xii) similarly notes: "*Although the book recognizes the value of techniques, it aspires to move faculty beyond them to conceptions of teaching that are more intriguing and intellectually rich*," and the book provides a powerful model of a developmental/experiential approach to faculty development. In *The Courage to Teach*, Parker Palmer (1998) refers to "*the boredom many of us feel when teaching is approached as a question of `how to do it'*" (p. 11) and offers the premise that "*Good teaching cannot be reduced to technique; good teaching comes from the identity and integrity of the teacher*" (p. 10).

On the other hand, most engineers and scientists come to instructional development programs much more interested in finding out what they should do in their classes starting next Monday than in cognitive theories, educational research, and personal explorations and self-revelation. If they suspect that a program is likely to focus on any of the latter topics, many will choose not to attend it or not to sit through it if they do attend, and they will be unlikely to adapt the ideas they hear to their teaching practice. Svinicki and McKeachie (2011, p. 3) observe, "*When you are just starting, discussions of philosophy of education and theories of learning and teaching can be helpful, but they are probably not as important as learning through techniques and simple skills to get through the first few weeks without great stress and with some satisfaction. Once some comfort has been achieved, you can think more deeply about the larger issues*."

As is usually the case with questions of theory vs. practice, the correct answer is, both. As Kant (or Marx or Lenin or Einstein, depending on the attributor) said, "*Theory without practice is sterile; practice without theory is blind*." Both are needed, in science and in instructional development. Engineering educators are trained scientists, accustomed to using critical thinking in their professional lives. If they are given a program that contains nothing but strategies and tips with no rigorous theoretical or empirical research support, few will see fit to change the way they teach. At the same time, if they only get general theories and educational research results or insights derived from reflection and sharing of personal experiences, and the translation of all of that into the context of teaching fluid dynamics or microprocessor design is left for them to work out, the desired changes are equally unlikely to occur. The right balance among practical teaching strategies, learning theories and research outcomes, and self-reflection depends on the needs, interests, and experience levels of the participants and the expertise and philosophy of the facilitators. The art of instructional development lies in finding that balance.

Deductive vs. inductive presentation. Pedagogical strategies, learning theories, and human developmental issues are each important components of instructional design, and a complete instructional development program should involve some balance of all three. The question then becomes, in which order should content in each area be presented? One choice is a *deductive* approach, starting with general theories of cognition and learning and human development and proceeding to apply the theories to deduce strategies for course and lesson planning, delivery, and assessment. The opposite is an *inductive* approach, which starts with specific observations and challenges, guides the participants to explanations and strategies, and then generalizes the results and provides the theoretical and research backing for the generalizations.

An argument for an inductive approach to instructional development is suggested by Fink *et al.* (2005), who observe that faculty members seeking to become better teachers tend to work through three increasingly sophisticated stages of development. Initially they try to learn about the nuts and bolts of teaching—making their lectures more interesting, writing better exams, using technology effectively, etc. They find that their teaching improves up to a point when they start using the strategies they learn, but they also recognize that there are still gaps between where their students are and where they want them to be. In the second stage, they are ready to learn what cognitive science teaches about how people learn and the conditions that favor development of high-level thinking and problem-solving skills. Their students' learning often improves dramatically when they apply their new understanding to their teaching practices. They may be content to stop at that point, but some of them may move to the third stage and adopt the even deeper goal of helping to prepare their students to reach their full potential for achievement and personal fulfillment in life. To do that, they need to learn about students' intellectual and personal development and how they as instructors can serve as mentors and role models for the developmental process. They are then ready to undertake instructional development of the type that Palmer (1998) advocates.

Once the content of an instructional development program has been selected, the question then arises of how the program might be structured.

FACULTY DEVELOPMENT PROGRAM STRUCTURES

Alternative Program Formats

Faculty development program elements generally fall into four categories: (1) workshops, (2) seminars and discussion sessions, (3) consulting, mentoring, and partnering arrangements, (4) learning communities. Each of these formats has variations, advantages, and disadvantages. A campus program may involve any combination of them.

Workshops. The most common structure for instructional development is workshops that last from several hours to a week. The workshops may be organized by campus centers for teaching and learning or by university or college administrators. They may address campus-wide audiences or focus on individual disciplines, such as engineering, or groups of related disciplines such as STEM. Besides being held on individual campuses, workshops directed at engineering faculty members are often given at professional society conferences. In the United States workshops have been offered for many years at the annual conference of the American Society for Engineering Education and the Frontiers in Education conference sponsored by the ASEE and the Institute of Electrical and Electronics Engineers (IEEE), and offerings at conferences in other countries are becoming increasingly common.

The principal advantage of a single workshop is that if it is well promoted, many participants are likely to attend, especially if the facilitators have good reputations. A disadvantage is that one-time events are relatively unlikely to have a lasting impact on most participants. The attendees may leave the workshop with good intentions and some may try implementing new practices, but in the absence of subsequent reinforcement their tendency is often to revert to more familiar but less effective methods.

On the other hand, pedagogical experts sometimes go overboard in criticizing single workshops. Relatively short workshops (two days or less) attract faculty members who would be unwilling to commit to longer one-time programs or a series of events spread out over a semester or academic year. Those individuals are made aware that there are alternatives to the traditional teaching approach, which is likely to be the only way of teaching they know. When they try those alternatives and get good results, some will keep using them, and they will be much more likely to participate in future programs that require more of a time commitment. Also, in every workshop there are likely to be a few individuals who have been dissatisfied with their teaching and are ready to hear about alternatives. Single workshops have had a dramatic impact on the teaching of some of those instructors, a few of whom have even been motivated to make faculty development a major focus of their subsequent academic careers.

Courses and seminar series. Another common structure is a series of sessions that take place over the course of a semester or academic year. The series may be a course open to graduate students and faculty members, regularly scheduled meetings of a faculty learning community with a fairly stable membership, or sessions on a variety of topics open to anyone interested. A session may involve a formal presentation by a speaker, a facilitated or unfacilitated discussion of a pre-assigned reading or topic, reporting and discussion of educational research projects or curriculum revisions, or open discussion.

A series of sessions attended by the same group of people can have a greater impact than a one-time seminar or workshop. Topics can be covered in greater depth in a series, and attendees can try suggested techniques following a session and report on the results and get feedback and guidance at the next session. The drawback of a series is that it can be difficult to persuade faculty members to commit to regular attendance, and dramatic drops in attendance after the first few sessions are common. The chances that a program will be successful are increased if incentives for participation are provided and if several colleagues from the same department participate.

Consulting, mentoring, and partnering. In a third program format, a faculty member works with another individual on improving his or her teaching.

- *Individual Consulting.* The faculty member may have one or more sessions with a resident expert, such as a staff member of the campus teaching center. The consultant may observe or videotape the consultee's teaching, conduct student focus groups or individual interviews with students, review student evaluations, or simply talk with the consultee and suggest improvements in his or her teaching. Faculty members who have attended workshops or courses are most likely to avail themselves of consulting services (Kolmos *et al.*, 2001). Lee (2000) discusses the difficulties that non-STEM consultants may encounter when dealing with STEM faculty members and suggests ways to overcome those difficulties, and Finelli *et al.* (2008) outline ways instructional consultations can be used to enhance the teaching performance of engineering faculty members.

- *Mentoring* (Felder, 1993). The faculty member either finds or is assigned (usually by the department head) an experienced colleague to function as a teaching mentor. Formal assignment generally works better than self-selection, for several reasons. Introversion keeps many new faculty members from asking more experienced colleagues to serve as mentors; it takes time for new faculty members to get to know their colleagues well enough to make a good choice; and not everyone who volunteers to be a mentor is qualified to be one. The mentor and mentee work together for a semester or academic year, perhaps co-teaching a course or periodically exchanging classroom visits and debriefing their observations afterwards. The key to a successful mentorship is meeting regularly: many so-called mentorships involve one or two initial meetings and invitations to the mentee to feel free to drop in and ask questions if problems arise, which mentees rarely do. Bland *et al.* (2009) provide many excellent ideas for initiating and maintaining successful mentoring programs, and Bullard and Felder (2003) offer an example of a successful engineering teaching mentorship.

- *Partnering*. The two previous arrangements involve expert-novice relationships. In the third one, peers in the same department or in different departments or disciplines support one another in an effort to improve their teaching. The arrangement may consist of two colleagues informally agreeing to periodic exchanges of classroom observations and debriefings over the course of a semester (Sorcinelli & Yun, 2007), or it may involve three or four faculty members exchanging visits and subsequently engaging in discussion sessions. The latter arrangement is sometimes referred to as *teaching squares* (Wessely, 2002).

Learning communities. Another instructional development structure involves forming a community of faculty members who organize themselves around individual or communal activities intended to improve their teaching and to provide support and guidance to one another (Cox, 2004). The activities may include reading articles and books on education, viewing and discussing videos and webinars, observing one another's classes, implementing selected teaching methods in their own classes, and conducting informal classroom research or formal (and possibly funded) educational research. There may be a group facilitator who gives presentations on topics of interest to the group but whose primary function is to provide encouragement and consulting assistance when needed. A learning community may arise simply when faculty members from the same department attend an instructional development workshop together, an occurrence that increases the subsequent likelihood of change in the department's teaching practices (Kolmos *et al.*, 2001).

Good examples of learning communities built around the scholarship of teaching and learning are found at the University of Lund in Sweden (Roxå *et al.*, 2008) and at Iowa State University in the United States (Jungst, Licklider & Wiersema, 2003). The second of these programs is Project LEA/RN (Learning Enhancement Action/Resource Network), whose elements include seminars, discussions of readings, paired classroom observations, and classroom research projects. Project LEA/RN has had a particularly broad impact since its inception in 1991, reaching 1200 educators at five universities and ten community colleges. Courter *et al.* (2004) describe the pilot study of a distance education-based learning community organized under the auspices of CIRTL (2010). In that program, engineering and science faculty members participate in weekly on-line instructional development sessions and report on individual classroom research projects.

Teaching Certification Programs

When explanations are sought for the low levels of participation in instructional development programs at research universities, the first one offered is invariably the low status of teaching in the faculty recognition and reward system. Fairweather (2005), for example, found that even at the most teaching-oriented colleges and universities, the more time faculty members spent in the classroom, the lower their salaries. One way administrators can convey the importance of teaching to the university and their high expectations for their faculties in this area is through a certification program that recognizes and rewards faculty members who complete a specified course of training. Certification attests to the individual's qualification to teach, either at a basic or advanced level. Requiring certification as a prerequisite to teaching is universally required in precollege education but not in higher education. The unstated assumption in the latter is that anyone who has studied a subject in college must be qualified to teach it. Anyone who has attended college knows how bad that assumption can sometimes be.

In reviews of certification programs around the world, Schaefer and Utschig (2008) and Utschig and Schaefer (2008) conclude that to be successful, programs should *(a)* be supported by a nationally respected society or academy, *(b)* include qualifying criteria or standards at several levels of expertise, and *(c)* accommodate flexibility in implementation across various university cultures. They describe a national certification program in the United Kingdom administered by the Higher Education Academy (HEA, website) that meets all three criteria. As part of its accreditation function, the HEA supports *Postgraduate Certificate in Higher Education Programs* at institutions of higher education in England, Scotland, Wales, and Northern Ireland. At some of those institutions, completion of a certification program is a condition for being awarded tenure. One such program conducted at Imperial College in London (Imperial College, website) includes face-to-face and on-line sessions on many aspects of teaching and assessment, research supervision, educational theories, technology, educational research, and teaching in the disciplines, plus two summative peer evaluations and preparation of a teaching portfolio.

Certification programs are in place in many countries. Kolmos *et al.* (2004) note that the primary vehicle for instructional development in Denmark is compulsory courses for new faculty members that involve a total of 175-200 hours and culminate with the preparation of a teaching portfolio. Completion of the program is a condition for promotion. The Ministry of Higher Education in Malaysia is moving towards making teaching certification compulsory for academic staff, with new faculty members at several universities now being required to complete a series of modules to obtain the *Certificate of Teaching in Higher Education* (Yusof, 2009). An international certification program specific to engineering education called ING-PAED (IGP, website) is administered in 72 countries by the International Society of Engineering Education in Austria. It consists of a series of core modules (engineering pedagogy and laboratory methodology), theory modules (psychology, sociology, ethics, and intercultural competencies), and practice modules (oral communications, technical writing, project work, and instructional technology), and is open to instructors with at least one year of teaching experience. Those who complete it are certified as "International Engineering Educators."

Critical Choices Regarding Program Structure

Campus-wide vs. discipline-specific programs. Roughly 70% of all U.S. research or doctorate-granting institutions have instructional development programs, most administered by campus centers for teaching and learning, and 40% of masters institutions have them (Kuhlenschmidt, 2009). The program elements generally include workshops for faculty members from all disciplines facilitated by campus administrators, educators or psychologists who address teaching-related issues, and computer systems administrators and programmers who deliver technology-related workshops. An alternative instructional development model provides workshops and seminars to faculty members in individual disciplines or groups of closely related disciplines, such as STEM. Table 3 summarizes the strengths of discipline-specific and campus-wide instructional development programs and suggests conditions for successful program implementation.

	Engineering- or STEM-specific	Campus-Wide
Suitable topics	• discipline-specific teaching and research • school-level services • department and school culture (including tenure & promotion requirements)	• discipline-independent teaching and research • campus policies, services, and facilities (including computer resources), and safety • employee benefits
Facilitators	• top teachers and researchers in the discipline(s) • deans, associate deans, & department heads	• campus faculty development staff • university-level administrators
Pros	• presenters understand participants' needs, interests, & problems related to teaching, research, and service • presenters have credibility with participants	• efficient and economical for discipline-independent topics • get cross-fertilization of ideas, build community across disciplines
Cons	• may fall below critical mass of participants in some years • possibly low cost-effectiveness	• absence of discipline-relevant examples
Conditions for success	• articulate facilitators with appropriate content knowledge and experience • active engagement of participants • practical, just-in-time content, with minimal emphasis on supporting research & theories (cite them but don't dwell on them) • opportunities for interactions among participants • good facilities, adequate staff support	

Table 3. Comparison of discipline-specific and campus-wide faculty development

Baillie (2003, 2007), Healy and Jenkins (2003), and McAlpine *et al.* (2005) have noted the importance of a balance of discipline-based vs. university-wide initiatives. Their arguments include that faculty members' primary allegiance is to their discipline (Jenkins, 1996); disciplinary thinking influences many teaching and learning tasks (Saroyan *et al.*, 2004); and university-wide initiatives generally do not generally lead to faculty members applying what they have learned to their own teaching environment (Boud, 1999). Sometimes programs targeted specifically to engineering or STEM disciplines are organized by teaching and learning centers based in the institution's engineering school, such as the Leonhard Center for the Enhancement of Engineering Education at Pennsylvania State University, the EnVision program at Imperial College-London, and the Engineering Learning Unit at the University of Melbourne. In other cases, one or more pedagogical experts with STEM faculty positions give the programs; and in still others the programs are organized by a central campus administrative unit and presented by teams of STEM educators and pedagogical experts in other fields.

The question of whether instructional development programs should be campus-wide or discipline-specific has the same answer as the question about whether programs should focus on theory or practice—namely, both are needed. In a seminal paper, Shulman (1986) observed that a false dichotomy had arisen in education between *content knowledge* (the facts, methods, and theories of the discipline and subject being taught) and *pedagogical knowledge* (theories and methods of teaching and learning independent of the discipline and subject), and introduced the vitally important bridge category of *pedagogical content knowledge* (representations of subject topics that maximize their comprehensibility to students; understanding which topics are easy and difficult and what makes them that way; and knowing the misconceptions students bring into class with them and how to correct them). A good teacher should have a high level of mastery in all three of these domains. With rare exceptions, individual faculty members do not possess such broad knowledge, which suggests the wisdom of instructional development partnerships between content experts and pedagogical experts.

In engineering, content experts usually reside in engineering departments and pedagogical experts are more likely to be found in campus centers or on education or psychology faculties. Ideally, teams of facilitators from each domain can be formed to present discipline-specific programs. If separate campus-wide and discipline-specific workshops are given, the key is to make sure that they are each done as effectively as they can be and that they function synergistically (Hicks, 1999). Ambrose (2009) proposes: "*If there is a central program, assure that the support people understand the domain of engineering. If there is an engineering program, assure that the support people understand more than engineering. If a university has both, make sure that the staff interact with each other!*"

External vs. local facilitators. Bringing in an outside expert to present a workshop has several attractive features. External presenters enjoy credibility that derives simply from the fact that they come from somewhere else and are being brought in at the institution's expense, and they can be sources of fresh ideas and role models to campus faculty developers. They can also convey the message that good teaching is a goal at many universities and not just a concern of the local faculty developer. If the presenter has a strong reputation and the workshop is well promoted, faculty members who are not normally inclined to go to teaching programs might be induced to attend, and if the program is skillfully conducted, it can stimulate them to try some new strategies.

On the other hand, external experts cannot provide sustained support for improving teaching since they are normally limited to one or two visits to a particular campus per year. Local experts can give courses on teaching, facilitate regular seminars and discussion sessions, and observe faculty members teaching and provide subsequent feedback. They can also organize and conduct follow-up sessions after presentations by external experts to help faculty members apply what they learned. Such sessions can play a vital role in assuring that the external presentations have the greatest possible impact.

For longer teaching workshops (a day and upwards), there is much to recommend team facilitation, with at least one facilitator from engineering or another STEM field and at least one with general pedagogical expertise. A good way to initiate such a program is to bring in an outside expert to give campus facilitators some training on effective instructional development for engineers and scientists. Without such training, the facilitators might have to work their way up a lengthy and steep learning curve, making their initial efforts less than effective, and the resulting word-of-mouth reporting could compromise continuation of the program. With the training, the chances of good initial workshops and long-term program sustainability both increase.

Sometimes teaching experts belong to the faculty of a specific department. They may have come from the department's discipline and made a decision to make teaching the focus of the remainder of their careers, or they may come from an education-related discipline and be "attached" to the department (as often occurs in the United Kingdom), or they may have been hired as a "teaching professor" (an increasingly common model in the United States).

Baillie (2007) suggests ways for an instructional expert within a department to have the greatest possible impact on the department's teaching program: (1) give an initial seminar in the department to establish credibility; (2) try for some "quick wins" such as the establishment of a peer tutoring program; (3) work with individual colleagues in a consulting role; (4) listen for the first months to understand key concerns, problems, and goals in the department. In all interactions with faculty colleagues, the pedagogical specialist should offer suggestions without being critical or prescriptive.

Mandatory vs. voluntary participation with and without incentives. Most instructional development programs are voluntary. Exceptions include programs for new faculty members that are required for promotion in Denmark, Norway, Sweden, and the United Kingdom, and at individual institutions in other countries.

The potential benefits of requiring faculty members to attend instructional development programs are obvious, but there are also dangers in doing so. Many who are forced to attend are likely to resent it, and program facilitators commonly become proxy targets for the administrators responsible for the requirement. The resentful attendees may simply withdraw from active engagement, or they may use frequent and aggressive questioning in an attempt to discredit the program content or the facilitators' expertise. Skillful presenters know how to handle difficult participants, but the confrontations diminish the experience for the majority of participants who are there to learn. The benefits of required participation are most likely to outweigh the risks when teaching is clearly an important component of the faculty reward system (particularly if it counts toward tenure and promotion in a meaningful way) and the program has an excellent reputation among past participants. If both of these conditions are not in place, required participation may be counterproductive.

If an instructional development program is voluntary, the risk is that too few engineering faculty members will attend for it to have a measurable impact on the school's teaching program. To minimize that risk, sometimes incentives are offered for participation. Possible incentives are cash or other tangible resources (such as computers), travel funds, or release from teaching or service responsibilities. Even token stipends can indicate that administrators are serious enough about teaching to be willing to invest money to improve it, which may induce significant numbers of faculty members to participate.

The importance of recognition and reward to the success of instructional development programs cannot be overemphasized. "*If quality teaching is not explicitly expected and rewarded as an institutional priority, faculty may feel that participation in such a program to strengthen teaching and improve student learning is not highly valued by administrators compared to other activities. Therefore, administrators may need to provide some form of external motivation for faculty participation*." (Romano *et al.*, 2004)

EVALUATION OF INSTRUCTIONAL DEVELOPMENT PROGRAMS

Although a considerable and growing body of work on instructional development program evaluation exists, most program directors simply administer participant satisfaction surveys, making little or no effort to determine how well their programs succeeded in meeting their objectives.

Chism and Szabó (1997) proposed that evaluation of an instructional development program can be performed at three levels:

- Level 1: How satisfied were the participants with the program?

- Level 2: What was the impact of the program on the participants' teaching knowledge, skills, attitudes, and practices? (To those measures might be added their evaluations by students and peers.)
- Level 3: What was the impact of the program on the participants' students' learning (knowledge, skills, and attitudes)?

An analogous system for evaluating corporate training programs is that of Kirkpatrick and Kirkpatrick (2006, 2007), who propose that evaluation can be performed at four different levels: *reactions* (which corresponds to Level 1), *learning* (Level 2–change in knowledge, skills, and attitudes), *behavior* (Level 2–change in teaching practices), and *results* (Level 3).

Table 4 summarizes some of the assessment measures that may be used to evaluate instructional development programs at each of the specified three levels.

Assessment Instrument or Outcome	**Notes**
Level 1 – Participant Satisfaction	
• End-of program satisfaction survey • End-of-program interviews • Retrospective survey & interviews	• Not a measure of program effectiveness (but probably a necessary condition)
Level 2 – Impact on Participants' Teaching Attitudes and Practices	
• Immediate post-program & retrospective surveys of attitudes and practices • Assessment of student-centeredness of teaching philosophy • Pre- and post-program student ratings of teaching • Pre- and post-program peer ratings of teaching	• Make sure rating form asks about targeted attitudes and practices, with items drawn from a professionally developed instrument with tested reliability and validity • Use a reliable peer rating protocol, not just one class observation (see Brent & Felder, 2004)
Level 3 – Impact on Participants' Students' Learning	
• Performance on standardized instruments or learning assessments of students taught before and after instructor's participation • Assessed program learning outcomes and course objectives • Students' tendency to adopt a deep approach to learning	• Make sure both groups of students have statistically equivalent entering credentials, and the assessment instruments address targeted skills and are valid and reliable

Table 4. Instructional development program evaluation.

Since the ultimate goal of teaching is learning, the true measure of the effectiveness of an instructional development program is the improvement in the participants' students' learning that can be attributed to the program (Level 3). Such improvements cannot be assumed to follow from their teachers' satisfaction with a workshop (Level 1), and may only be inferred indirectly from changes in the teachers' instructional practices, attitudes, and evaluations following workshop attendance (Level 2). The Level 3 question is therefore the one that matters most, and if we could get an unequivocal answer to it there would be little need to ask the other two.

Unfortunately, it is difficult to obtain that answer, and next to impossible to obtain it such that observed improvements in learning can be unequivocally attributed to participation in the instructional development program. For that reason, evaluation generally consists of asking participants to rate the programs and the facilitators on some scale and perhaps to comment on things they liked and disliked (Level 1), or asking program alumni to retrospectively evaluate the effects of the program on their teaching (Level 2). Chism and Szabó (1997) found that 85% of the instructional development programs on the 200 campuses they surveyed assessed at Level 1. It is of course important to assess participant satisfaction to identify problems and obtain guidance on how to improve subsequent offerings, but satisfaction surveys provide no indication of the subsequent impact of the workshops on either teaching or learning. Fewer than 20% of Chism and Szabó's respondents indicated that they always or usually evaluate the impact of programs on the participants' teaching (Level 2), and none attempted to evaluate impact on students' learning.

The validity of using participants' self-assessments of their teaching as part of a Level 2 workshop evaluation has been examined by D'Eon *et al.* (2008), who cite a number of studies that compared self-assessments of teaching with external evaluations by trained observers. Those studies support two conclusions:

- An individual's assessment of his or her teaching skill before or after a workshop cannot be taken at face value, but aggregated self-assessments from workshop participants generally match closely with external assessments and can provide the basis for a valid and reliable evaluation of workshop effectiveness.
- Individual gains in skill calculated from separate pre-workshop and post-workshop self-assessments are also suspect, since before the workshop individuals often lack a legitimate basis for judging their skill levels. On the other hand, individuals' retrospective (post-workshop) self-assessments of pre-post workshop gains in skill levels correlate reasonably well with more objective external ratings. Skeff *et al.* (1992) reached the same conclusion in a study of a medical instructional development program.

Numerous publications report Level 2 evaluations of instructional development programs, most of which involved retrospective assessments of program participants' teaching attitudes and practices and in some cases their student ratings before and after their participation (Brawner *et al.*, 2002; Camblin & Steger, 2000; Conley *et al.*, 2000; Estes *et al.*, 2010; Felder & Brent, 2010; Fink *et al.*, 2005; Gibbs & Coffey, 2004; Ho *et al.*, 2001; McAlpine *et al.*, 2005; Postareff *et al.*, 2008; Strader *et al.*, 2000). Gibbs & Coffey (2004) and Postareff *et al.* (2008) used the *Approaches to Teaching Inventory* (Trigwell & Prosser, 2004) to determine where the participants' conceptions of teaching fell on a continuum between teacher-centered (transmission of information) vs. learner-centered (facilitation of learning). One study (Ho *et al.*, 2001) used the *Course Experience Questionnaire* (Ramsden, 1991) to assess students' perceptions of the course and instruction, and another (Gibbs & Coffey, 2004) used a subset of the *Student Evaluation of Educational Quality* (Marsh, 1982) for the same purpose. Significant numbers of survey respondents indicated that their teaching had improved in their estimation and/or that of their students, and many reported adopting learner-centered teaching practices and conceptions of teaching that had been advocated in the programs they attended.

Level 3 evaluations are much rarer. McShannon *et al*. (2006) examined the effectiveness of a program in which participants were trained in teaching methods designed to address different student learning styles and were then observed teaching classes and given individual feedback. Student cohorts taught by those instructors were compared with cohorts taught the same classes by the same instructors in the previous year. The grades earned by the experimental cohorts were on average 5.6% higher for freshmen and 6.7% higher for sophomores, and retentions in engineering were 7.8% higher for first-year students and 12.9% higher for sophomores, with all of those differences being statistically significant.

Ho *et al.* (2001) used the *Approaches to Studying Inventory* (Entwistle, 1992) to assess students' approaches to studying (surface vs. deep) at the beginning and end of courses taught by program participants, and Gibbs and Coffey (2004) did the same thing using the *Module Experience Questionnaire* (Lucas *et al*., 1997). In the latter study, the questionnaire was also administered to a control group of non-participating teachers and their students. A matched-pair study showed that the students taught by the trained instructors were significantly less likely to take a surface approach to learning following the training and slightly more likely to take a deep approach. No change in approach occurred in the students taught by the untrained instructors. Assessing students' approaches to learning falls short of a direct Level 3 evaluation, but numerous studies have shown that students who take a deep approach display a wide range of superior learning outcomes relative to students who take a surface approach (Meyer *et al*., 1990; Ramsden, 2003).

MAKING ENGINEERING INSTRUCTIONAL DEVELOPMENT EFFECTIVE

Theoretical Foundations

Instructional development involves teaching adults, and the same theories, principles, and heuristics that have been validated for adult education by cognitive science and/or empirical educational research should be applicable to instructional development (King & Lawler, 2003). A critically important determinant of the effectiveness of teaching adults is the students' motivation to learn (Hofer, 2009; Wlodkowski, 1999, 2003). In a review of corporate training programs, Quiñones (1997) cites a number of studies demonstrating that trainees' motivation to learn has a significant effect on how effective a program is for them. Incorporating anything into the design and delivery of an instructional development program that increases the participants' motivation to learn the content should therefore increase the program's effectiveness.

Wlodkowski (1999) suggests that five attributes of a learning environment have a motivational effect on adult learners (Table 5). We hypothesize that those five attributes should provide a good basis for the design of engineering instructional development programs.

Factor	Rationale
1. *Expertise* of presenters	Adults expect their teachers to be experts in the material being taught, well-prepared to teach it, and knowledgeable about the interests, needs, and problems of their audience.
2. *Relevance* of content	Adults may quickly become impatient with material they cannot easily relate to their personal interests or professional needs.
3. *Choice* in application	Adults respond well when given options about whether, when, and how to apply recommended methods, and are skeptical of "one size fits all" prescriptions.
4. *Praxis* (action plus reflection)	Adults appreciate opportunities to see implementations of methods being taught and to try the methods themselves, and then to reflect on and generalize the outcomes.
5. *Groupwork*	Adults enjoy and benefit from sharing their knowledge and experiences with their colleagues.

Table 5. Factors that motivate adult learning (Wlodkowski, 1999)

Another well-validated model for effective instruction is the cognitive science-based *How People Learn* (HPL) framework (Bransford *et al*., 2000; VaNTH-ERC, website). The HPL criteria are compatible with Wlodkowski's motivational factors.

- The HPL framework calls for a *learner-centered* environment, which takes into account the knowledge, skills, and attitudes of the learners. This environment is promoted by establishing the *relevance* of course material and giving learners the freedom to make *choices* among alternatives. Learner-centeredness is also supported by having at least one workshop facilitator who comes from a discipline similar to that of the participants and shares their content knowledge (*expertise*). Moreover, active learning, which when done effectively involves both action and reflection and can almost be considered synonymous with *praxis*, is almost invariably included on lists of learner-centered teaching methods.

- HPL calls for a *knowledge-centered* environment, meaning that the content being taught should focus on the most important principles and methods associated with the subject of the presentation and should build on the learners' current knowledge and conceptions, and the presentation should utilize techniques known to promote skill development, conceptual understanding and metacognitive awareness rather than simple factual recall. Wlodkowski's *relevance* factor covers the first of those conditions, and *praxis* fosters high-level skills and metacognition if the activities require such skills and are followed by reflection and feedback on the outcomes.

- HPL calls for an *assessment-centered* environment, suggesting that feedback be regularly provided to help learners know where they stand in terms of meeting the learning objectives of the instructional program. Giving the participants opportunities to practice recommended techniques and providing immediate feedback on their efforts (*praxis*) helps to establish such an environment.

- The final HPL requirement is a *community-centered* environment characterized by supportive interactions among learners and de-emphasis of individual competition. Both conditions are consistent with Wlodkowski's *groupwork* criterion.

It is consequently reasonable to suggest that an instructional program for adult learners that meets all five of Wlodkowski's criteria also complies with the HPL framework. As long as such a program is well organized and has skilled facilitators and a good classroom environment, it is likely to be effective and well received by the participants.

The ineffectiveness of many campus-wide workshops for engineering instructional development is understandable in the light of Wlodkowski's conditions for adult learner motivation (Table 5). While educators and educational psychologists may be experts on pedagogical theories and good teaching practices, they usually lack the disciplinary content knowledge to construct examples that would make the workshop material clearly applicable to engineering courses. Even if the presenters had that knowledge, they would probably refrain from using it for fear of losing participants from other disciplines in campus-wide workshops. Many engineering faculty participants consequently cannot see the *relevance* of the workshop material to what they do, and they are also likely to erroneously conclude that the presenters lack the *expertise* to tell them anything useful about their teaching. Teaching workshops are often prescriptive, giving the participants no *choice* in whether, when, and how to implement each recommendation. The participants get the message that they have been teaching wrong and must make the all of the recommended changes to be acceptable teachers, a message most do not appreciate. Finally, some workshops consist almost entirely of lectures on educational theories and methods, with little opportunity for *praxis* (practice and reflection) in the methods and little or no content-related *groupwork* among participants.

Example: The ASEE National Effective Teaching Institute

The National Effective Teaching Institute (NETI, website) is a three-day teaching workshop given in conjunction with the ASEE Conference. Since 1991, it has been attended by 1047 engineering faculty members from 220 institutions. In the early spring of 2008, a web-based survey sent to 607 workshop alumni asked about the effects of the NETI on their teaching practices, their students' and their own ratings of their teaching, their involvement in educational research and instructional development, and their attitudes regarding various aspects of teaching and learning. Valid responses were received from 319 of the survey recipients, for a 53% rate of return. The complete survey and full analysis of the results is given by Felder and Brent (2009), and a synopsis of the results and their implications for engineering instructional development is given by Felder and Brent (2010).

Substantial percentages of the respondents incorporated learning styles, learning objectives, and active learning (the concepts most heavily emphasized in the workshop) into their teaching following their participation in the NETI. Fifty-two percent of the respondents felt that the NETI motivated them to get involved in instructional development; 44% had engaged in it (9% extensively and 35% occasionally), and 21% had not yet done so but planned to in the future. High percentages of the respondents reported engaging in practices that characterize scholarly teaching: 89% read education-related journal articles and 73% had participated in an education conference, with roughly half of each group having been motivated to do so by the NETI; and 69% belonged to the ASEE, roughly a third of whom were persuaded by the NETI to join. Three-quarters of the respondents had engaged in classroom research and/or formal educational research, with 50% having been stimulated to do so by the NETI. In their open-ended responses, many participants indicated that as a result of participating in the NETI, they had become more effective and/or more learner-centered and/or more reflective in their teaching. Felder and Brent (2010) proposed that the success of the NETI derives in large measure from the extent to which it meets Wlodkowski's criteria, giving specific examples of workshop features that directly address the criteria.

Increasing the Appeal and Relevance of Instructional Development to Engineers

There are two broad approaches to making engineering instructional development effective: (1) modifying programs to make them more appealing and relevant to both new and experienced engineering faculty members, and (2) changing the campus climate to make continuing professional development an expectation for all faculty members. This section offers recommendations in the first category and the next one deals with the second category.

Many faculty development experts and teaching leaders have presented suggestions for increasing the effectiveness of instructional development programs (Eble & McKeachie, 1985; Eggins & Macdonald, 2003; Felder & Brent, 2010; Fink, 2006; Garet *et al.*, 2001; Hendricson *et al.*, 2007; Ho *et al.*, 2001; Kahn & Baume, 2003, 2004; Lockhart, 2004; Sorcinelli, 2002; Sorcinelli *et al.*, 2005; Sunal *et al.*, 2001; Weimer, 2010; Wright & O'Neil, 1995). Most of the suggestions either directly or indirectly address one or more of the five factors of Wlodkowski's theory of adult motivation to learn (Table 5). The following list applies them specifically to engineering instructional development.

- *Be sure program facilitators have expertise in both engineering and pedagogy*. Except in those rare cases where such expertise resides in a single individual, programs should be facilitated by teams that collectively provide these qualifications. Content expertise can be provided by engineering teaching leaders, while pedagogical expertise can be supplied either by campus teaching and learning center staff or by education or psychology faculty members. (*Expertise, relevance*)
- *Use external facilitators strategically*. External facilitators should be used to attract a wide audience, lend visibility and credibility to instructional development efforts, and provide expertise not available on campus. (*Expertise*)
- *Use engineering-related examples and demonstrations to the greatest possible extent.* The closer program content is to the sorts of things the participants teach, the less likely they will be to dismiss the content as irrelevant to their work. (*Relevance*)
- *Target program content to the needs and interests of the participants.* For new faculty members, emphasize basic instructional issues and strategies. Midcareer and senior faculty members can benefit from programs that introduce advanced pedagogical approaches such as cooperative and problem-based learning, information on modern cognitive theories and models, and exploration of attitudes and values related to teaching and learning. *(Relevance)*

- *Provide choices in application of recommended methods.* Effective instructional development programs should not mandate the adoption of new strategies (as in "You can only be an effective teacher if you use active learning!"). The facilitators should instead outline strategies and invite participants to try two or three that look reasonable in their next course rather than setting out to adopt every program recommendation starting on Day 1. Above all, there should be no intimation that the teaching methods the participants have been using (such as lecturing) are wrong. The idea is not for them to stop using those methods but to gradually supplement them with new ones. (*Choice*)
- *Model recommended techniques and provide as many opportunities as possible for participants to practice them and formulate applications to their own courses*. (*Praxis*)
- *Actively engage the participants.* Adult learners like having the chance to try out recommended techniques and to offer their own ideas based on their experience. Programs that consist almost entirely of lectures without such opportunities are likely to be ineffective. (*Groupwork*)

Creating a Supportive Campus Culture

Weimer (2010, p. xiii) asks, "*Why don't more faculty take advantage of professional development opportunities?*" and responds "*Because there are no consequences if they don't.*" Fink (2009) articulated the crucial role of administrators in motivating faculty members to participate in instructional development programs and maximizing the impact of the programs on institutional teaching quality:

> *On many campuses, the faculty correctly perceives the view of the administration toward participation in instructional development to be: "If you want to participate in this, that is OK; if you don't want to, that is OK too." So long as that is the faculty perception, you will only get the 20% or so of faculty who are "eager learners" to regularly participate. What we need is for the organization to send a clear message that in essence says: "Teaching at this institution is a major responsibility and we view all faculty members as professional educators. As such, they should engage in regular and continuous professional development directly related to their roles as educators." Then and only then will we get the rate of participation up from 20% of all faculty to where it ought to be, 80% to 100%.*

Following are recommendations for creating a campus culture in which continuing professional development is an expectation for all faculty members:

- *Make it clear in position advertisements, interviews, and offer letters that participation in faculty development is a job requirement, and add a section to the yearly faculty plan or activity report called "professional development."* (Fink *et al.*, 2005; Fink, 2006)

- *Evaluate teaching meaningfully, taking into account assessments of course design and student learning, peer ratings, and alumni ratings along with student ratings. Then take the results into account meaningfully when making personnel decisions*. The more heavily the evaluation outcomes count in decisions regarding tenure, promotion, and merit raises, the more faculty members will be motivated to participate in instructional development and the better the institutional teaching quality will become. (Felder & Brent, 2004; Fink *et al.*, 2005; Fink, 2006)

- *Recognize faculty members' efforts to improve their teaching and reward their success in doing so.* Nominate excellent teachers for local, regional, national, and international awards, and publicize successes to the same extent research achievement is publicized.

- *Encourage direct administrator participation.* Personally taking part in instructional development programs helps deans and department heads understand the developmental needs of their faculty members. If the programs are good, the administrators may subsequently be inclined to increase their moral and financial program support, and if they publicly announce their intention to participate, faculty enrollment tends to rise.

Questions for Research

The recommendations given above for making engineering instructional development effective are based on evaluations of successful programs, suggestions from a diverse group of faculty development authorities and teaching leaders, and a hypothesis that conditions known to motivate adult learners and facilitate student learning should also promote effective instructional development. As yet, however, there is no validated framework for instructional development program design, and most of the recommendations are empirically grounded but nonetheless speculative. Answering the following questions should help confirm the extent to which they are valid.

- *What conditions are necessary to obtain a valid Level 3 evaluation (determining the impact of the program on the participants' students' learning)? What (if any) sufficient conditions can be formulated? Under what conditions can Level 2 evaluation (determining the program impact on the participants' teaching practices, attitudes, and student and peer ratings) provide a valid proxy for Level 3?*

- *How sound is the recommendation to focus on effective pedagogical practices in programs for relatively inexperienced faculty members and to place a greater emphasis on exploration of learning theories and teaching-related attitudes and values in programs for more experienced faculty members?*

- *How effective at promoting lasting change are different program structures (single workshops, seminars and discussion series, consulting, mentoring, partnering, learning communities, and teaching certification programs)?*

- *Under what conditions are discipline-specific instructional development programs more effective than campus-wide programs and vice versa?*

- *Under what conditions are program facilitators who come from fields outside engineering effective with engineering faculty members?*

- *Under what circumstances (if any) should participation in instructional development programs be mandatory?*

- *How effective are different incentives offered to engineering faculty members to attend voluntary instructional development programs? What differences in post-workshop changes exist between attendees who would go under any circumstances and those who go specifically because of incentives?*

- *How sound are the recommendations offered in this section for broadening the appeal and relevance of engineering instructional development programs? Can any of the recommendations be considered necessary conditions for program effectiveness? Can any subset of them be considered sufficient?*

- *How effective are on-line instructional development programs compared to their traditional counterparts? What conditions maximize their effectiveness?*

- *Which (if any) engineering schools have created cultures that support and reward effective teaching and instructional development? What actions and policies were responsible for the success of their efforts?*

Answers to these and similar questions will be needed to help engineering school administrators and instructional development personnel gain a nuanced understanding of what makes engineering instructional development effective for specified target audiences and program outcomes. Our hope is that another review of engineering instructional development in five years or less will include a validated research-based framework for effective program design and delivery.

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Appendix
Glossary of Selected U.S. Academic Terms and International Synonyms

- *Faculty development.* "Some form of organized support to help faculty members develop as teachers, scholars, and citizens of their campuses, professions, and broader communities" (Sorcinelli *et al.* 2005, p. *xiii*). Faculty development programs may include efforts to enhance faculty members' teaching, research, and administrative skills and to facilitate their personal development, to modernize courses and curricula, to promote the scholarship of teaching and learning, and to redesign organizational structures and policies (including faculty reward systems) to better support the previous functions. The term *educational development* originated in Canada and is now used in several European countries as well to cover all aspects of faculty development related to teaching and learning (Saroyan & Frenay, 2010), and the terms *staff development*, *academic development*, and *professional development* (which takes into account the development of research skills) are also widely used to cover some or all faculty development functions.
- *College of engineering, school of engineering.* The personnel (including faculty members, administrators, technicians, secretaries, other employees, and students) and other resources that comprise the academic unit devoted to teaching and research in engineering. In some countries this entity might be referred to as the *faculty of engineering*.
- *Course.* A semester-long (or quarter-long) unit of instruction on a particular topic that may include lectures, recitations (also known as *tutorials* or *problem sessions*), laboratory sessions, regular assignments, projects, and examinations. In some countries the term *discipline* would have this meaning. The term *class* is sometimes used synonymously with course, although it might also mean the group of students taking a course.
- *Faculty, faculty members.* The collection of individuals at a university who teach courses and/or conduct research and are not students. In most countries these people would collectively be called *staff* or (to distinguish them from support personnel such as secretaries and lab technicians) *academic staff*. They include tenured and untenured professors, associate professors, assistant professors, research professors, teaching professors, instructors, and lecturers.
- *Grades.* Numbers or letters (A, B, C+,…) given by instructors to rate students' performance levels in courses, examinations, and assignments. The term *marks* is more common in many countries when applied to examinations and assignments.
- *Graduate students.* Students who have received their initial university degrees and are enrolled for advanced study, possibly leading to masters or doctoral degrees. In other countries they would be referred to as *postgraduate students*, and students who are called *undergraduates* in the U.S. would be called graduate students in some of those countries (such as Brazil).
- *Instructional development***.** A subset of faculty development (and educational development) specifically intended to help faculty members become better teachers.
- *Tenure.* In the United States and Canada, after a period usually between four and six years, a faculty member may be granted tenure by a vote of their department faculty and approval of higher administrators. Tenure is tantamount to a guaranteed permanent faculty position, although a tenured faculty member can be fired for extreme incompetence or criminal conduct or if the faculty member's academic unit (department or program) is eliminated. In other countries, such as those in the UK, the term does not exist but after several years of competent performance faculty members automatically move into a permanent position.
- *University.* Any institution of higher education. We will use this term to denote all institutions that have "university," "college," or "institute" in their names.