AC 2011-1781: WRITING EFFECTIVE EVALUATION AND DISSEMINATION/DIFFUSION PLANS

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Writing Effective Evaluation and Dissemination Plans for Innovations in Engineering Education

Introduction

The importance of assessment in engineering education has been on a steep rise for more than a decade because of accreditation requirements for data-driven decisions on improvements in courses and curricula. This increased emphasis on classroom assessment has not, however, resulted in a noticeable improvement in the quality of the evaluation plans in proposals to the National Science Foundation (NSF) for course and curriculum development or for engineering education research. A large fraction of proposals to NSF still have weak evaluation plans,[1] in spite of the fact that resources exist to assist with the formulation of evaluation plans. Among these resources are an overview of assessment methods by Olds et al.,[2] *Scientific Research in Education*,[3] and *Knowing what students know: the science and design of educational assessment*.[4]

In addition to expectations for high quality assessment and evaluation plans, new guidelines for Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) proposals have also raised expectations for outcomes of dissemination efforts. The guidelines indicate that projects to develop innovations in engineering education must include plans to persuade and enable other educators to adopt those innovations.

Processes by which innovations are adopted and adapted by others are studied under an umbrella field often referred to as 'diffusion of innovations'.[5] We will adopt this terminology in the remainder of the paper and use the term dissemination/diffusion plan to make clear that more than dissemination is now expected.

Unfortunately, effective methods for dissemination/diffusion of course, curriculum, and learning innovations are even less developed within the engineering education community than methods for evaluation. A search of the engineering education literature turned up only a handful of references on dissemination. In an article on designing a dissemination plan, Froyd[6] provides a framework for choosing appropriate tools for dissemination (reproduced in Table 1).   Fincher[7] offers three guiding principles for dissemination and a hierarchy of types of dissemination.

Based on the need to improve the evaluation and dissemination/diffusion plans in NSF proposals to develop innovations in engineering education, a proposal to hold a workshop on these topics was submitted to the Division of Undergraduate Education (DUE) under the Course, Curriculum, and Laboratory Improvement (CCLI) program. The ultimate goal of the project was to create a document that would assist engineering educators in writing effective plans for their proposals to NSF. This paper documents events of that workshop and the resulting outcomes.

Table 1. Dissemination/Diffusion methods at different stages of faculty change (Froyd)

Very High………………………..Responsibility for External Initiation……..……………………..Very Low				
Very Low…………...Receiver ownership………………..………..............Very High				
Awareness	**Interest**	**Search**	**Decision**	**Action**
One page summary of a curricular project Flyers Short videos Brochures with brief descriptions of selected results	Longer summaries of a curricular project Short multimedia CD-ROM	Journal publications Conference proceedings Website containing project descriptions, instructional materials, assessment and results	2-4 hour workshops offered at conferences or on site CD-ROM containing entire website	1-2 day workshops Course manuscripts Project descriptions Example lesson plans

Summary of Workshop Process and Outcomes

The workshop was organized by an interdisciplinary team from psychology, educational psychology, and engineering education. The workshop participants were similarly interdisciplinary; they included engineering faculty members, department heads and graduate students as well as experts in assessment and evaluation. A total of 28 individuals were involved in the workshop, six from the organizing team, nineteen participants, and three NSF program officers.

During the workshop, four interdisciplinary teams were presented with a case study that described innovations in engineering education. (The case study is presented in Appendix A.) Each team worked through the process of creating evaluation and disseminations plans for a specific innovation described in the case study.

Each team was asked to monitor their process for creating the evaluation and dissemination plans so that they could summarize the process during reports to the entire group. After the workshop, the organizing team synthesized the workshop output into a set of guiding questions and major findings. The sets of questions are intended to guide engineering educators through a systematic process as they begin to construct evaluation and dissemination/diffusion plans. In addition, several major observations were derived from the overall experience at the workshop. These were also included in the workshop report.

Following the creation of the first version of the report, the guiding questions were used in a workshop delivered at the Annual Conference of the American Society for Engineering Education (ASEE) in June 2010. Feedback was solicited from participants to improve the report, which led to revision of the report. Subsequently, the PIs hosted a workshop for faculty and staff involved in engineering education research at their home institution to solicit critical comments to improve the report. After a second round of revisions, the report reached its final form. The full workshop report can be retrieved from www.evaluationanddissemination.weebly.com.

The project evaluator conducted observations and surveys for the original workshop, held in April 2010, and the ASEE workshop. A post-workshop survey was administered to determine the extent to which the participants were using the guiding questions in their work as well as to solicit suggestions on how to improve the report and how to disseminate it more effectively. The feedback from participants indicated that the experience was very valuable to them, especially the interaction between engineering educators and the colleagues with expertise on learning and measurement. Evaluations from the participants at the ASEE workshop also indicated that they found the experience to be useful, though several suggested making the workshop more interactive.

The post-workshop survey occurred approximately four months after the original workshop and two months after the ASEE workshop. 13 responses were received from a total of 37 participants, a response rate of 35%. 10 of the 13 participants indicated that they had shared the information with colleagues. 9 of 13 respondents indicated that they been involved in the preparation of an NSF proposal subsequent to the workshop. Of those 9, 8 had used the guiding questions for evaluation as part of their process. Only 4 of 9 reported using the dissemination/diffusion guiding questions.

The remainder of this paper summarizes the major findings from the workshop and the two sets of guiding questions.

Key Findings from Workshop

As mentioned above, we identified five key findings related to writing assessment and dissemination plans that went beyond the sets of guiding questions. These findings are:

- *Developing evaluation and dissemination/diffusion plans is an iterative process.* The order in which the guiding questions are presented should not be interpreted to represent a rigid process, but rather as guides to help you along the pathway to creating effective plans. The process will require both jumping ahead to later questions and looping back to earlier questions. We recommend that you overview all questions prior to beginning your work.

- *Evaluation and dissemination/diffusion plans should be explicitly linked together.* As groups did their work during the workshop, it also became quite clear that intent to persuade others to adopt/adapt an innovation requires that evaluation plans include the collection of persuasive evidence. Accordingly, evaluation plans and dissemination/diffusion plans are intimately linked. Writing high quality evaluation and dissemination/diffusion plans will involve bridging from one plan to the other and back again.

- *Synergies among the learning scientists[1] and engineering educators can be powerful.* The workshop reinforced important synergies and benefits of bringing together engineering educators and learning scientists. A consistent finding across working groups was that the interaction of members from an interdisciplinary team made significant, positive contributions throughout the process. We, therefore, strongly encourage all engineering educators who decide to use our guiding questions to seek a partner with expertise in learning and measurement as early as possible in the process of creating the evaluation plans.

- *The team writing the plans, and the proposal, should include at least one learning scientist.* A team with a complementary set of experiences, expertise and training will assure an optimal evaluation strategy for the proposed project. The team should be assembled as early as possible in the planning of the project to ensure that the evaluation strategies best match the planned work, and also so that the planned work is guided by contemporary learning theories.

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[1] "Learning scientists are dedicated to the interdisciplinary empirical investigation of learning as it exists in real-world settings and how learning may be facilitated both with and without technology." The field encompasses many disciplines including cognitive science, educational psychology, education, and sociology. Reference: Website of the International Society of Learning Scientists (www.isls.org)

- *Interdisciplinary teams must be mindful of the potential for miscommunication.* The experience at the workshop made clear that differing backgrounds and vocabularies used by the various team members may lead to communication issues. For example, the engineering community has come to use terms like outcome and objective, as a result of ABET, in ways that are different from their use in the fields related to learning. Be sensitive to these differences and try to avoid wasting time arguing over semantics. The specific terms used are far less important than the meaning behind them.

Guiding Questions for Evaluation Plans

In formulating an evaluation plan for an NSF-proposal on innovations in engineering education, it is important to keep in mind that there will be two major uses of evidence collected during the project: (i) to establish to what extent an innovation is effective, and why it is effective, and (ii) to help persuade others that your innovation is something that they should adopt/adapt.

The workshop that generated this list of questions was focused on projects designed with the intention of improving student learning. Often this type of project has the goal of creating a new activity or process that will be put in place to improve student learning. Such activities and processes are often referred to as an '*intervention'* in the education literature.

Please note that the guiding questions have been written in the second person because they are addressed to those who will read, and hopefully use them.

The guiding questions for evaluation plans are listed below. The full discussion of them taken from the workshop report is presented in Appendix B.

- What are the intended goals of the project? For learning focused projects, this question could be stated as "What do you want the students to achieve?"

- Based on your project goals, can you write a set of hypotheses for your project?

- What evidence that the project has achieved its intended goals will be convincing? If you are able to construct hypotheses for your project, this question could also be stated as: What evidence will allow you to accept or refute the hypotheses?

- In order to generalize the results of the projects, it is also important to ask the following question: Why did the project achieve its intended goals?

- What are possible sources of evidence?

- What overall design is appropriate for your study, e.g., can you use a design with a control group?

- Is the plan complete, yet appropriate to the scale of the overall project?

- Where can I go to find additional information on writing evaluation plans?

Guiding Questions for Dissemination/Diffusion[2] Plans

In formulating an dissemination/diffusion plan for an NSF-proposal on innovations in engineering education, it is important to keep in mind that the data collected in the project will be used (i) to establish to what extent an innovation is effective, and why it is effective, and (ii) to persuade others that your innovation is something that they should adopt/adapt.

If you are thinking from the beginning of the design process about the dual use of the data, you will be more likely to see ways in which you can use data for both evaluation and dissemination/diffusion leading to a more efficient and effective set of plans.

The guiding questions for the dissemination/diffusion plans are listed below. The full discussion of them taken from the workshop report is presented in Appendix C.

- How can you design your innovation to maximize the chances that others will adopt/adapt it for their use?

- What audiences do you hope to reach with your dissemination/diffusion efforts?

- What type of action is desired for each selected audience?

- Where are your selected audiences, not only in terms of location, but also in terms of awareness of the type of innovation you are advocating, their motivation to adopt/adapt your innovation, etc.?

- Can you anticipate potential points of resistance to taking the desired action and be prepared to deal with them?

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[2] Processes by which innovations are adopted and adapted by others are studied under an umbrella field often referred to as 'diffusion of innovations'[2]. We adopt this terminology in this report and use the term dissemination/diffusion plan to make clear that more than dissemination is now expected. Please see the introduction for additional discussion of this point.

- What type of evidence is needed to persuade each target audience to take the desired action?

- For a given audience, what are persuasive methods of presenting the evidence and through what channels are they effectively delivered?

- Is there work in the literature on diffusion of innovation, marketing, etc. that can inform my decisions? Are there papers describing how engineering education scholars were able to get others to adopt their innovations?

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References

[1] Pimmel, Russ and Sheryl Sorby, "Writing Proposals to Meet NSF's Expectations," Workshop at 2008 ASEE Annual Meeting, Pittsburgh, PA, June 22, 2008.
[2] Olds, Bar: Evolution, Approaches, and Future Collaborations, Journal of Engineering Education, Vol. 94,No. 1, pp. 13-25 (2005)
[3] National Research Council, Committee on Scientific Principles for Education Research, **Scientific Research in Education**, Richard Shevelson and Lisa Towne, Editors, National Academy Press, Washington, DC (2002)
[4] National Research Council, Committee on the Foundations of Assessment, **Knowing What Students Know: The Science and Design of Educational Assessment**, James W.Pellegrino, Naomi Chudowsky, and Robert Glaser, Editors, National Academy Press, Washington, DC, 2001
[5] Rogers, E. M. (2003). *Diffusion of Innovations (fifth ed.)*. New York, NY: Free Press.
[6] Froyd, Jeffrey, Developing a Dissemination Plan, Proceedings of the 31st ASEE/IEEE Frontiers in Education Conference, October 2001.
[7] Fincher, Sally, From Transfer to Transformation: Towards a framework for successful dissemination in engineering education, Proceedings of the 30th ASEE/IEEE Frontiers in Education Conference, October 2000.

Appendix A: Workshop Case Study

Case Study

A Mechanical Engineering program at a large research university is undertaking a major curriculum initiative with the intention of improving learning through greater use of problem-based learning and also through explicit instruction on meta-cognitive aspects of learning. It is believed that the increased use of problem-based learning will engage students with a wider range of cognitive styles and that the instruction in meta-cognition will lead to increased success in learning, and therefore greater satisfaction and greater retention of students.

In addition, this Mechanical Engineering program plans to implement new project topics that go beyond traditional areas to demonstrate to students that Mechanical Engineering can directly affect individual lives. The new projects will involve applying Mechanical Engineering knowledge and skills to assist disadvantaged individuals and groups. One set of projects involves meeting the needs of people with physical and sensory disabilities. Another engages the special challenges associated with aging such as the increasing likelihood of falls and bone breakage from those falls. A third set of projects will involve assisting small villages in developing countries by, for example, designing and implementing sustainable energy generation systems for schools.

The major tasks of the curriculum initiative are:

1. All required engineering science courses will include a minimum of two mini-projects from the new thematic areas. The projects will evolve in sophistication and level of challenge as students progress through their years of study. A formal process for approaching complex problem solving will also be introduced in the first required course and used throughout all of the courses. This iterative process, based on the work of Woods at McMaster University, includes the following stages: explore and define problem, create model, plan solution, execute solution, evaluate solution and solution process. Workshops will be held to assist faculty members in understanding and adapting the problem-solving process in their teaching and in creating the mini-projects for their courses.

2. Projects related to the new thematic areas will be added to all design courses. The ME program has a three course design sequence; students typically take these courses in the first, fifth and eighth semesters. Direct interaction with potential users of the devices, through meetings and trips, will occur in the fifth and eighth semester courses. The design report for the eighth semester project will require students to describe their experiences in working with the users of their designs and how those experiences made them feel about themselves as Mechanical Engineers. To support implementation of this task, workshops will be held to assist instructors in creating the design projects and planning for the interactions between their students and the users of the devices and the reflective portion of the eighth semester design report.

3. One-half of the experiments in required laboratories on instrumentation, materials, dynamic systems, and controls will be restructured so that they relate to testing of devices related to the new thematic areas. Each lab course will also include one ‘self-directed’ lab in which students will identify a problem of interest to them in one of the new thematic areas, and then design and conduct an appropriate experiment. Workshops will be offered to assist instructors in developing the new labs and also in planning for the implementation of the ‘self-directed’ labs. Graduate teaching assistants are heavily involved in teaching these lab courses. A workshop will be organized for the graduate teaching assistants and the instructors so that the teaching assistants

will be prepared for teaching the new labs and for supporting students as they undertake the self-directed lab.

4. Along with the revisions of the curriculum, this initiative will also put in place new instructional methods to raise students' awareness of the importance of meta-cognitive processes, such as self-explanation and critical analysis, to successful learning and to help students to practice and improve these processes. Because few faculty members are familiar with meta-cognitive processes and ways to teach them, faculty workshops are also planned in this area.

Appendix B: Guiding Questions for Evaluation Plans

What are the intended goals of the project? For learning focused projects, this question could be stated as "What do you want the students to achieve?"

At the outset, the intended goals for the project should be identified. The team should consider the following questions: "What will be different as a result of this project?" Goals can range from changes at the institutional level (e.g., a new course will be adopted), course level (e.g., a new set of activities will be incorporated in an existing course), instructor level (e.g., engineering educators will have a better understanding of X), to the student level (e.g., improved problem solving processes). Sample goals from the workshop are presented in Table 2.

If the project focuses on what students can do or what they understand, i.e., the cognitive domain, the team should settle on the specific concepts and the depth to which students should learn them. In addition, the anticipated skills developed should be specified.

Another question the team could address is the extent to which anticipated learning will 'transfer.' In the education literature, transfer is defined as the application of knowledge to novel content or situations and is one objective of interventions intended to affect student behaviors in future settings or in relation to new problems. Transfer is viewed as existing on a continuum from 'near' to 'far' transfer. Near transfer occurs when knowledge is applied in novel, but similar ways or contexts. Far transfer requires knowledge application in highly dissimilar ways.

Acquisition of conceptual and procedural knowledge rarely occurs in isolation; instead, it is very frequently connected to development in affective and meta-cognitive domains. *Affective* refers to students' attitudes, feelings and emotions; it includes the important, but extremely complex variable, motivation. *Meta-cognitive* refers to a learner's ability to monitor, plan, and control learning. For example, meta-cognition encompasses the ability to monitor the level of understanding and judge whether it meets the students need, e.g., to pass an exam. Meta-cognition also includes the ability to decide what strategies are best for a given situation.

While engineering faculty members frequently focus on cognitive development, they may ignore or pay less attention to affective and meta-cognitive development. However, development (or lack thereof) in these two domains may significantly enhance (or hinder) cognitive development with respect to learning goals. Attending to affective and meta-cognitive development (another example of the value of collaboration with faculty members with expertise on learning) may increase likelihood of project success.

Table 2: Example project goals created by workshop participants for Task 1 in the case study (Appendix):

- Improved achievement of the existing learning outcomes of the courses in which mini-projects are implemented
- Improved problem solving processes by students as a result of learning and using a formal methodology for complex problem solving.
- Transfer of problem solving process to follow-on courses
- Improved ability of faculty members to teach the problem solving process and coach students in its use.
- More complete and meaningful course projects created by Instructors

Based on your project goals, can you write a set of hypotheses for your project?

‘Hypotheses’ are testable assertions about the intended effects of the project. Take as an example, the type of design projects that are used in engineering courses, such as a project in which design technology use to assist people with special needs such as those who are visually impaired or elderly who have reduced mobility.

The same projects could be used to achieve different goals. In a first-year design class, such projects might be used to enhance the awareness among the students that engineering can directly affect the quality of life for individuals, with the intention of increasing the diversity of students who decide to stay in engineering after their first year.

In this case, a testable hypothesis would be that “students who have completed mini-design projects for people with special needs will be more likely to remain in engineering than those who do not.” The literature on motivation and development of professional identity could provide possible reasons that this intervention would be successful. Those reasons could also be tested as part of the evaluation process.

Not all projects lend themselves to the development of hypotheses. Exploratory research intended to generate findings on a particular question is one example where hypotheses may not be possible. Such research may in fact have the goal of generating testable hypotheses that can be explored in follow-on research. An exploratory research project could investigate a question such as: What are the major challenges that students encounter as they learn to create mathematical models in thermodynamics?

What evidence that the project has achieved its intended goals will be convincing? If you are able to construct hypotheses for your project, this question could also be stated as: What evidence will allow you to accept or refute the hypotheses?

You will need to write multiple answers to this question because you will need to convince different audiences that the project achieved its goals. The first audience to be considered is the research team itself, i.e., for each hypothesis, the team must determine what evidence would convince team members that their work was successful. A second audience to be considered is the set of outside reviewers who will evaluate the evidence. These reviewers include NSF panel members and reviewers of publications from the project. A third audience includes other academic institutions and instructors who the team hopes will use the results of their project. This third audience forges direct links to the design of the dissemination/diffusion plan.

In order to generalize the results of the projects, it is also important to ask the following question: Why did the project achieve its intended goals?

Answering the question of <u>why</u> the project worked requires different data than answering the question of <u>whether</u> it worked. For the example of design projects for people with special needs described above, answering this question could start with an investigation of the literature on motivation to select a theoretical framework that would suggest which aspects of design projects will be most likely to influence students retention in engineering.

In this phase of the work, it is also important to identify alternative explanations of why the intervention worked so that they can be ruled out, ideally, in the overall design of the evaluation plan. An alternative explanation refers to an explanation other than a hypothesized effect that can account for the same pattern of findings. A quality evaluation plan will include measures that can be used to rule out these alternative explanations. To do this, the team should brainstorm alternative explanations for anticipated findings and consider measures that would clearly identify causal components.

What are possible sources of evidence?

To answer this question, start by brainstorming a long list of possibilities with the intention of paring down the list later. Consider both qualitative (written and oral communication, focus groups, interviews) and quantitative (frequencies, scores, multiple choice responses) sources of evidence. Consider ‘formative’[3] as well as ‘summative’[4] sources of evidence.

Student work such as prototypes, reports, or presentations, are acceptable sources of evidence, and a relatively efficient one as well because there is no extra work on the part of the students to generate the evidence. There is work required to analyze it, however. For research involving student projects, you may want to consider gathering information relating to process that will show *how* a student develops a product or completes an activity, such as direct observation or

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[3] Formative processes are intended primarily to support improvement, e.g., improvement of student learning during the course, improvement of course design from one semester to the next, etc.
[4] Summative processes are intended primarily to support conclusions, judgments, or conclusive evaluations.

video. Some of the possible sources of evidence considered by workshop participants are presented in Table 3.

Before completing the brainstorming phase, ensure that you have at least a few ideas that will provide evidence relating to each of your project goals. An evaluation plan is strengthened when multiple sources are used to evaluate each claim. This is called ‘triangulation’ and serves to strengthen your claims.

For quantitative work, it will be necessary to comb the literature for instruments that you can use in your research. Development of new instruments and validation of their use is a long and painstaking process – it is best to leave it to the experts. However, preexisting instruments must be critiqued to examine reliability and validity evidence and to be sure that the instruments match the project goals; such information should exist in publications by the developers of the instrument. On the qualitative side, the literature should be searched for appropriate examples of protocols for data collection and analysis. (Time spent in the literature at this stage may save you lots of work and will likely save you from “reinventing the wheel.”)

For projects that are developing a specific intervention, method, or tool, such as a virtual laboratory, you should also consider the type of evidence that will allow you to judge whether the tool is being used as you intended. For example, you may want to observe or talk to students about how they used the tool instead of just relying on finished products or outputs. Such evidence will allow you to refine the tool to ensure that it is being used as intended and will eliminate the need to second guess that question when you analyze the evidence to decide if the tool is working and why it is working.

Table 3. Possible sources of evidence considered by workshop participants related to the goals for Task 1 in the case study (Appendix) were:

- **Pre- and post-tests** as evidence of improvement in achieving learning outcomes for the engineering science courses.
- **Written reports** for mini-projects in engineering science classes that includes description of their problem solving methodology/approach to document understanding of the process.
- In capstone design course, let students approach problem via **design project**, and see if they’re using the design process (which they’ve been taught) if it wasn’t specifically required – evidence of understanding and use of process, as well as, of transfer to other classes.
- **Think-aloud sessions** in which students talk about what they are thinking as they work through a design case as evidence of understanding and use of the problem solving process.
- **Direct observations or videotapes** of students working in groups; analyze for evidence of language related to the problem solving process and explicit use of processes in the problem solving process

What overall design is appropriate for your study, e.g., can you use a design with a control group?

Answering this question can be very challenging. Engineering faculty members often think in terms of improvement, which must be translated to mean that something is better than something else. In this case, it almost always follows that one group of students that is the focus of the intervention must perform “better” than one or more control groups. Although these control-experimental group designs may be ideal, they are often difficult to achieve in the higher education or informal learning settings that characterize engineering education. We seldom have sufficient control over enrollments in various sections of a course, and if we do, then the effect could be confounded with time/date, student, or instructor effects. In other words, it is very difficult to prove that differences between two groups of students are in fact due to the treatment and not differences between the groups themselves, the time the class was offered, or the person teaching the course.

Given all of this, however, choosing an overall design that involves one or more control groups will appeal to many of the audiences that the project intends to influence, so these approaches should be considered. The learning science research literature provides examples for different cases. Special education research often deals with the challenges of small sample size, and cognitive science research provides examples of using various comparison groups to sort out the effects of different variables or sample characteristics. Collaborators trained in these disciplines can be particularly helpful in these cases.

Is the plan complete, yet appropriate to the scale of the overall project?

Related questions include: Is each individual goal addressed? How or by whom will the evidence be collected? Do some pieces of evidence need to be processed (e.g., scored) to create data? If so, who will be responsible for this? Can some sources of evidence do double-duty in addressing multiple goals? (This is perfectly acceptable, and perhaps valued for efficiency.) Are resources available to complete the entire evaluation plan tasks in the time allotted? Do you have adequate incentives in place in order to ensure that participants will engage in the evaluation process?

Is the proposed plan appropriate to the effort of the intervention, course, or program, or is it over-designed? Related to this question, consider the limitations of your evaluation plan. Particularly for smaller scale projects, you may not be able to explore every possible hypothesis in your evaluation plan.

In addition, consider whether your evaluation plan will allow for competing explanations of findings due to factors other than the effectiveness of the intervention. For example, if different instructors will be using the same intervention, the teaching style of each instructor may potentially influence the credibility of your findings and your ability to claim all measured benefits are due solely to the intervention.

Where can I go to find additional information on writing evaluation plans?

- *OERL: On-line Evaluation Resource Library* http://oerl.sri.com

"The web site is organized by types of evaluation resources (e.g., plans, instruments, reports) and types of projects (e.g., Curriculum Development, Teacher Education). The collection of over 130 instruments contains student assessments, questionnaires, interview protocols, observation protocols and other types of instruments. The collection of 38 plans and 60 reports contains complete and excerpted versions, with accompanying explanatory annotations. Criteria for sound evaluation practices drawn from the Program Evaluation Standards, 2nd ed. (Joint committee on Standards for Educational Evaluation, 1994) are presented for each type of evaluation resource. In addition, guidelines and scenarios explain how the evaluation resources can be used or adapted and how OERL users can take advantage of the capabilities of the online, interactive environment."

- *The 2002 User-Friendly Handbook for Project Evaluation*
  http://www.nsf.gov/pubs/2002/nsf02057/nsf02057.pdf
  This handbook "is aimed at people who need to learn more about both what evaluation can do and how to do an evaluation, rather than those who already have a solid base of experience in the field. It builds on firmly established principles, blending technical knowledge and common sense to meet the special needs of NSF and its stakeholders."

- Assessment in Engineering Education: Evolution, Approaches and Future Collaborations (2005) Barbara M. Olds, Barbara M. Moskal, and Ronald L. Miller, Journal of Engineering Education, Vol. 94, No. 1, 13-25.

- Knowing What Students Know: The Science and Design of Educational Assessment (2001) Committee on the Foundations of Assessment, James Pellegrino, Naomi Chudowsky, and Robert Glaser, Editors, National Academy Press, Washington, DC

Appendix C: Guiding Questions for Dissemination/Diffusion Plans

How can you design your innovation to maximize the chances that others will adopt/adapt it for their use?

This question forges a link to the design and development of your innovation. If you seek widespread adoption/adaptation of your innovation by other educators, you must avoid the use of special facilities and methods not commonly used by engineering educators. Or you must find ways to help your selected audiences create the needed facilities and to develop the requisite skills. If you are developing an online intervention, you should use an interface that would not be dependent on university-specific course management systems and could be easily adapted for any institution.

What audiences do you hope to reach with your dissemination/diffusion efforts?

In answering this question, you must be realistic in terms of what you can do within the scope of your project. Therefore, you must be strategic and focused in your selection of audiences. Larger scale, Type 2 and Type 3, projects will likely have a greater focus on persuading others to adapt the innovation that has been developed. Possible selected audiences could include:

- Faculty members at your home institution
- Faculty members at institutions geographically close to project institutions
- Faculty members at institutions with existing connections to yours, e.g., institutions in a system, institutions in a particular state
- Faculty members in a particular discipline, e.g., mechanical engineering, that could be influenced through several channels, including professional societies
- Faculty members at institutions of types similar to project institutions, e.g., community colleges, similar size
- Faculty members who might already be aware of project innovations, e.g., faculty members who have published papers on similar innovations.

Depending upon the scope and type of innovation that you are investigating, it might also be useful to consider audiences beyond faculty members. Leaders such as Department Heads and Deans might be appropriate audiences, particularly if they need to provide resources for their faculty and students to use your intervention.

What type of action is desired for each selected audience?

You should consider a spectrum of actions that ranges from making the audience aware of your innovation to having them adapt it for use that at their institution. The spectrum of actions you consider will be driven by the response you desire. For example, you might want to generate strong interest among Department Heads so that they will advocate for your innovation within their faculty. Or you might wish to get a certain fraction of colleagues at your home institution to adopt your innovation.

Where are your selected audiences, not only in terms of location, but also in terms of awareness of the type of innovation you are advocating, their motivation to adopt/adapt your innovation, etc.?

Members of your selected audience may be aware of the innovation and seeking more information. People like these may invest time and effort in seeking and processing information about the innovation. Others may be unaware of the innovation and initially will invest few resources in learning more. In general, different types of persuasive materials may be effective with different people, depending on their prior knowledge of and experience with the type of innovation.

Can you anticipate potential points of resistance to taking the desired action and be prepared to deal with them?

In considering your actions, you must reflect upon your selected audience and understand the reasons why they may resist taking the action that you desire. If you do this, you can be prepared to engage their resistance when it arises.

For example, resistance can arise because of

- Accessibility, e.g., “I can’t find it or download it.” or “I don’t have access to that journal.”
- Portability, e.g., “Our institution is not like your institution, so I cannot adapt your materials.”
- Adaptability, e.g., “I cannot modify what you share because of the nature of your innovation.”

What type of evidence is needed to persuade each target audience to take the desired action?

Note that this question builds an explicit bridge to the evaluation plan. If you wait until the ‘dissemination/diffusion’ stage to consider this question, you will have missed many opportunities to collect the evidence you need.

For a given audience, what are persuasive methods of presenting the evidence and through what channels are they effectively delivered?

Formulating the materials in ways that will be most persuasive to your intended audiences will take time and creative thought. For example, you can prepare project summaries that could be mailed to colleagues. But you must think about the amount of time they will spend in reading it; a post-card length document might be most effective as a first step.

There are many channels that are commonly used for dissemination such as presentations at conferences, technical papers and websites. Unfortunately, such channels may raise awareness of your innovation, but they are rarely effective in persuading others to adopt/adapt an innovation. Therefore other approaches must be considered such as:

- Invite faculty members to visit one or more of your project institutions
- Invite faculty members to review and/or contribute to project material development early enough in the process that their input can influence development
- Form an advisory board for your project with members representative of your primary audience and/or leaders who can influence others
- Offer mentoring/cognitive apprenticeship opportunities for faculty to learn how to use your innovation
- Create short videos on your innovation for posting on You Tube and Teacher Tube
- Use social networking channels
- Use students as ambassadors
- There are several initiatives related to the Open Content Alliance that may be useful: (http://www.opencontentalliance.org/) with initiatives to make course content accessible, including the MIT Open Courseware initiative (http://ocw.mit.edu/OcwWeb/web/home/home/index.htm), the Connexions project (http://cnx.org/), and the NSF National Science Digital Library program (http://nsdl.org/).

In answering questions about which channels might be most appropriate and effective for your project, collaborations with colleagues from marketing and communications could likely prove to be very helpful. The need to drive diffusion of innovations may make such collaborations as commonplace as those now enjoyed between engineering educators and colleagues from the education, psychology, and educational psychology.

Is there work in the literature on diffusion of innovation, marketing, etc. that can inform my decisions? Are there papers describing how engineering education scholars were able to get others to adopt their innovations?

There are at least two bodies of literature relevant to development of dissemination/diffusion plans. One body of literature, diffusion of innovations, studies how innovations are propagated across a broad community of users. Investigators might consider the following resources as starting points:

- Rogers, E. M. (2003). *Diffusion of Innovations (fifth ed.)*. New York, NY: Free Press.
- Wejnert, B. (2002). Integrating Models of Diffusion of Innovations: A Conceptual Framework. *Annual Review of Sociology, 28*, 297-326.
- Borrego, M., Froyd, J. E., & Hall, T. S. (2010). Diffusion of Engineering Education Innovations: A Survey of Awareness and Adoption Rates in U.S. Engineering Departments. *Journal of Engineering Education*, *99*(3).
- Froyd, J. E. (2001). *Developing a Dissemination Plan*. Paper presented at the Frontiers in Education Conference. Retrieved 10 November 2008, from http://portal.acm.org/citation.cfm?id=1253531.1254677
- Strang, D., & Soule, S. A. (1998). Diffusion in Organizations and Social Movements: From Hybrid Corn to Poison Pills. *Annual Review of Sociology, 24,* 265-290.

The second body of literature, organizational change, studies how change agents promote adoption of change within an organization. Investigators might consider the following resources as starting points:

- Weick, K. E., & Quinn, R. E. (1999). Organizational change and development. Annual *Review of Psychology, 50*, 361-386.
- Clark, M. C., Froyd, J. E., Merton, P., & Richardson, J. (2004). The evolution of curricular change models within the Foundation Coalition. *Journal of Engineering Education, 93*(1), 37-47.
- Kezar, A. J., & Eckel, P. D. (2002). The effect of institutional culture on change strategies in higher education: Universal principles or culturally responsive concepts? *The Journal of Higher Education, 73*(4), 435–460.
- Senge, P. M., Kleiner, A., Roberts, C., Roth, G., Ross, R., & Smith, B. (1999). *The Dance of Change: The Challenges to Sustaining Momentum in Learning Organizations*. New York: Doubleday Currency.
- Woodbury, S., & Gess-Newsome, J. (2002). Overcoming the Paradox of Change without Difference: A Model of Change in the Arena of Fundamental School Reform. Educational Policy, 16(5), 763-782.
- Henderson, C., Finkelstein, N., & Beach, A. (2010). Beyond dissemination in college science teaching: An introduction to four core change strategies. *Journal of College Science Teaching, 39*(5), 18-25.