Persuading Professors: A Study of the Dissemination of Educational Reform in Research Institutions

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Abstract

What does it take to persuade research university professors to try something new in their classrooms? In this exploratory study, qualitative research methods were used to investigate how chemistry and mathematics instructors at research universities responded to four different dissemination approaches: (a) unsolicited mailings of dissemination materials, (b) electronic website postings that allowed users to order materials, (c) seminar presentations given by a reformer followed by mailings of materials, and (d) minicourses given by reformers who distributed their own materials. Samples of faculty members who had experienced each approach were selected and interviewed by phone 4-6 weeks after they had received materials. The interviews explored the strengths and weaknesses of each dissemination approach and investigated the personal and contextual factors which influence the likelihood that professors will implement a reform. Interview analysis uncovered three different stages to encouraging someone to adopt a reform, with each stage favoring different dissemination approaches. Effective dissemination was found to be a process of catching users at the right time with the right dissemination approach, one that was neither too detailed nor too abstract for the user's current level of interest and understanding. Approaches that allowed some form of personal contact between the reformer and the potential user were preferred by the vast majority of professors, as were approaches that were readily accessible and convenient. Also, research professors were more likely to be open-minded and comfortable about trying reforms endorsed by an esteemed colleague or research institution.

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1. Introduction

What does it take to persuade research university professors to try something new in their classrooms? Over the last decade, the National Science Foundation's Education and Human Resources Directorate has made a major investment in encouraging education reform. At the same time, it has found that relatively few of the reform programs it has supported make the shift from the "successful pilot reform" stage to the "successful institutionalized reform" stage (Millar, 1995). Because knowledge dissemination and utilization remain persistent "weak links" in the EHR's education reform process, an exploratory study was undertaken by researchers at the University of Wisconsin's LEAD (Learning through Evaluation, Adaptation, and Dissemination) Center to discover what makes the dissemination of reforms in higher education more effective.

1.1. Past research on the dissemination of reform

Past research on the dissemination of education reform has suggested that change is a "highly personal experience"(Loucks-Horsley & Stiegelbauer, 1991) and that reforming one's educational practices must feel like a personal choice if it is to succeed. Even if reforms are mandated from above, the instructors being asked to change their practices must either be able to "personalize" the reforms by aligning them with their previous practices in some way, or they must feel convinced by their own experiences that a true change is in order (Berman & McLaughlin, 1978; Cohen & Ball, 1990; Fullan & Promfret, 1977; Huberman & Miles, 1984; Kozma, 1985). As it happens, the former is more likely than the latter. As both Kozma (1985) and Loucks-Horsley and Stiegelbauer (1991) have argued, the reform process is almost always evolutionary and incremental. Radical and sudden change rarely if ever occurs—rather, new instructional practices are built on top of previous instructional practices. As a result, reforms are most likely to succeed when instructors can see congruence between the reform practices and their own pedagogical beliefs and when they can find a "bridge" between what they have always done and what they are now attempting to do.

In his study of how the faculty at small colleges responded to two different educational reforms, Kozma (1985) further found that reforms are more likely to take hold in a given setting when there is a group, rather than just an individual, involved in the original decision to adopt a reform. The group or "collaborative" mode of reform is far less common than the individualized mode but far more successful in promoting institutionalization because "the adoption process is cooperative, and ownership of the project is shared" (p. 311). With the individualized mode, by contrast, the reform is generally perceived as strongly associated with just one charismatic individual and his or her personal teaching style, and once that individual moves on, the reform dies out. With the collaborative mode of reform, dissemination of the reform is typically carried out through informal and personal interactions between colleagues who have tried the reform and those who have not.

In their review of the literature on reform dissemination, Hutchinson and Huberman (1993) similarly found that personal contact between colleagues is how most successful reforms are spread. While educational research findings in and of themselves may sometimes persuade teachers who are already reform-minded to try something new in their classrooms, having a respected fellow teacher attest that a reform worked for them goes much further in convincing

other teachers to try it. In part, this is due to the fact that educational researchers and practitioners belong to separate discourse communities with very different perspectives and ideologies (Beyer & Trice, 1982). Many teachers distrust the opinions of people who are not themselves "down in the trenches" trying to teach, and they often regard the suggestions of educational researchers as either too vague or too impractical to put into practice. This researcher/practitioner split makes the dissemination of education reforms all the more difficult, since many of the studies which demonstrate that a reform actually "works" are performed by educational researchers and written up for an audience of fellow researchers.

1.2 The current study

Hutchinson and Huberman (1993) describe the dissemination and utilization process as having three successive stages: adoption—the decision to use a reform; implementation—the actual use of a reform; and institutionalization—the routinized use of a reform. The current study focuses on the first stage in this process, adoption. While past research on the spread of education reform has generally examined how a reform "takes hold" at an institution once a faculty member has made the decision to implement the reform in his or her own classroom, the current study explores what leads faculty members to decide to use a reform in the first place. What set of circumstances cause instructors to be receptive to reform? How do instructors hear about a given educational reform, and what prompts them to want to learn more about it? What factors do they consider in deciding whether to try a particular reform, and what are the institutional incentives or disincentives for pursuing it?

Previous research in reform dissemination has also focused on teachers at postsecondary schools or at small private colleges, both of which place a strong emphasis on teaching. Little research has been done about disseminating reform information to professors and instructors at large to mid-sized research universities, where teaching is often considered secondary to one's research efforts. Because there is comparatively little incentive for research university professors to improve their teaching, this group of instructors is especially resistant to investing the time and effort necessary to institute educational reforms. Yet this group of instructors is responsible for teaching over 44% of the nation's undergraduates (NCES, 1993). Moreover, this group trains almost all future college and university faculty and the majority of future K-12 teachers. What it will take to persuade instructors at these larger universities to reform their teaching practices remains unclear. It is for this reason that the current study was undertaken.

In the study reported here, qualitative research methods were used to investigate how chemistry and mathematics instructors at large to mid-sized research universities responded to four different dissemination approaches. The approaches were: (a) unsolicited mailings of dissemination materials, (b) electronic website postings that allowed users to order dissemination materials, (c) seminar presentations given by a reformer/practitioner followed by mailings of dissemination materials, and (d) hands-on minicourses given by reformer/practitioners who distributed their own materials during the mincourse. These four dissemination approaches vary in the pre-existing interest level of the audiences they tend to target and in the degree to which they enable this audience to interact with the reformer/practitioners and their classroom exercises. Our study considered each approach in the context of the other factors that bear on a faculty member's

decision to try an educational reform. For example, what leads professors to be open or closed to a given educational reform and which of these factors are beyond a disseminator's control? One hypothesis explored by this study is that, when it comes to actually prompting change in faculty practice, more interactive dissemination approaches like talks and workshops are more effective than less interactive approaches like disseminating printed information through the mail or the Internet. This hypothesis is supported by research that shows learning and knowledge utilization are better when the learner is more actively engaged with the new material (Bruffee, 1992, 1996; Fullan, 1991: Hutchinson & Huberman 1993; Lave & Wenger, 1991; Rogoff, 1990; Vygotsky, 1978; Wertsch, 1991). However, it may also be the case the effectiveness of each dissemination approach varies depending on what stage of the decision-making process the recipient is in (Loucks-Horsley & Stiegelbauer, 1991). As Hutchinson and Huberman (1993) suggested in their review, some dissemination activities are best suited to increasing awareness or giving basic information to people who know little or nothing about a reform, while others are best suited to teaching the already-interested how to implement the reform.

2. Research design and methodology

To explore the effectiveness of the four dissemination approaches, we selected samples of faculty members who had experienced each approach and interviewed them by phone 4-6 weeks after they had received dissemination materials. These structured, open-ended interviews were used to explore the strengths and weaknesses of each dissemination approach and to investigate the impact that each approach had on faculty members' willingness to enact the educational reform described. In addition, the interviews enabled us to uncover personal and contextual factors which either expedited or hampered attempts to implement demonstrably effective reforms. This study was not meant as a controlled comparison of the effectiveness of the four dissemination approaches but as an exploratory study of how faculty members respond to and utilize the information provided by each approach.

2.1. The four dissemination approaches

The four dissemination approaches we examined are ones that are frequently used by disseminators of reform in higher education. Each approach is described in detail below.

2.1.1. Approach A: Unsolicited mailings (chemistry & mathematics)

Dissemination Approach A was the least interactive and the least specifically targeted toward professors who were already interested in educational reform. For this approach, we randomly called chemistry and mathematics departments from large to mid-sized research universities across the nation and asked for the names and addresses of general chemistry instructors and calculus instructors who taught there. We then mailed dissemination packets about a calculus reform (the Wisconsin Emerging Scholars program) to 25 of the calculus instructors and dissemination packets about a chemistry reform (Materials Enriched General Chemistry) to 25 of the general chemistry instructors. Enclosed with each packet was a cover letter from the LEAD Center briefly describing the reform and the success with which it had been used in courses at the

University of Wisconsin-Madison. The letter suggested that the materials in the packet might be of interest to the recipient and encouraged recipients to take the time to review them, but it did not mention that the packets were sent as part of a dissemination study.

2.1.2. Approach B: Website postings followed by mailings (mathematics only)

Dissemination Approach B was somewhat more interactive and better-targeted than Approach A in that subjects ordered the dissemination packet themselves after seeing a descriptive posting about it on a math reform electronic website. A more popular version of this approach is to put the dissemination materials themselves online, but for the purposes of our study we needed to have interested readers order the materials through the mail so that we could obtain their names and addresses. Attempts were made to post announcements on both chemistry and mathematics-related websites, but only the mathematics-related sites accepted our posting in time for the study. Three electronic announcements about the WES program were placed: one on the Math Forum/Calculus Reform page (forum.swarthmore.edu/mathed/wes.html), one on the Mathematics Association of America Online's Teaching & Learning page (www.maa.org/t_and_l/), and one in the National Council of Teachers of Mathematics online News Bulletin (www.nctm.org). The announcements appeared on the electronic websites for a period of 3 months, during which a total of 50 packets were ordered by web-browsers who filled out and emailed an electronic order form to the LEAD Center. Packets were sent out with a cover letter similar to that used in Approach A.

Incidentally, NCTM's News Bulletin also has a paper version that is mailed to subscribers worldwide, and our announcement appeared in that version as well. This paper announcement generated 51 packet orders, some from as far away as Botswana, but only a small portion of the math instructors who ordered the packet this way were from the population we wished to study, and only two of these were available for interviews. These two interviews are included under Approach B.

2.1.3. Approach C: Seminar presentation followed by mailings (chemistry only)

During the summer of 1996, noted UW-Madison Chemistry Professor Art Ellis was invited to Florida State University and Iowa State University to give hour-long presentations on his reform effort, Materials Enriched General Chemistry. These talks were organized by professors at both universities who were already committed to reforming their department's introductory chemistry courses and were shopping for ideas on how to go about it. Both talks involved 50-minute seminar presentations and demonstrations of the materials, followed by 10 minutes of questions, and both were well-attended by faculty members, graduate students, and some undergraduates from the host institution's chemistry department. Because Dr. Ellis wanted to obtain permission from attendees before they were sent packets related to our study, he contacted attending colleagues a few months after each talk and asked them if they would be willing to participate in the dissemination study. Hence, in contrast to Approaches A and B, the professors in Approach C knew they were part of a dissemination study when they were sent the packets. Those who said yes were sent packets about MEGC and were then contacted by a LEAD researcher 4-6 weeks later to schedule phone interviews.

2.1.4. Approach D: Minicourses with materials included (mathematics only)

Because there was not enough lead time during our study to schedule conference minicourses on either WES or MEGC, we instead studied minicourses led by non UW-Madison reformers regarding two college-level math reforms. Like the WES program, the reforms used group work and challenging open-ended problems to actively engage learners in exploring mathematical concepts. The two minicourses were sponsored by the Mathematical Association of America and were held during the American Mathematical Society and Mathematical Association of America Joint Meeting in San Diego in January of 1997. Each minicourse cost $45 to attend and consisted of two 2-hour sessions scheduled over two or three days. During these sessions, the reformer/practitioners used cooperative learning and group work to demonstrate their reform activities to mathematicians from a variety of backgrounds. Twenty people attended Jim Sandefur and Rosalie's Dance's minicourse entitled "Technology, Modeling, and Cooperative Learning, Putting it All Together," while 17 people attended Phyllis Chinn and Dale Oliver's minicourse entitled "Active and Interactive Teaching Techniques for the Mathematics Classroom." The reformers distributed their own dissemination materials (primarily how-to handouts and exercise worksheets) during the workshops themselves. A LEAD researcher received permission from both groups of reformers to attend and observe their minicourses as part of our study and to interview participants a month later. Participants were told during the workshops that they were being observed as part of an NSF-sponsored study and that they might be called for interviews in the months that followed.

2.2. The reforms and the associated dissemination materials

There were four separate reforms included in our study, each with its own set of dissemination materials. The reforms and materials are described briefly below.

2.2.1. Materials Enriched General Chemistry (MEGC)

MEGC curricular materials, developed by UW-Madison's Dr. Art Ellis in cooperation with chemistry faculty around the nation, use easy-to-grasp solid-state demonstrations and a solid-state model kit to incorporate materials science into the general chemistry curriculum and to illustrate key chemistry concepts in ways that are quite literally "hands-on." Evaluations conducted by Dr. Ellis have found that the use of these materials not only captures students' interest but makes chemistry seem less abstract and more applicable to the types of materials that students encounter outside of the lab. Other changes Dr. Ellis has made to his general chemistry course are designed to prepare students for the type of learning and teamwork situations that they will encounter in the modern workforce. These changes include the use of group work and collaborative learning on homework assignments, replacing the grading curve with an absolute scale, the use of in-lecture "ConcepTests" to make lectures more interactive and more attuned to the students' understanding, and the use of a graduated "hint" system on exams that allows students to be docked a few points on their exams in exchange for clues about problems they have trouble solving. Students enrolled in the current version of his course have earned higher course grades than students from previous semesters and have shown greater satisfaction with the course and what they have learned from it.

The packet of dissemination materials regarding this reform contained the following:

- *Treating students and industry as customers*, a scholarly article written by Dr. Ellis for ChemTech that describes the innovations used in his general chemistry course.
- *"You Do Teach Atoms, Don't You?": A Case Study in Breaking Curriculum Reform Gridlock*, a narrative booklet by LEAD Center researchers that tells the history and development of Dr. Ellis' reform project and provides an evaluation of the reform.

2.2.2. The Wisconsin Emerging Scholars program

This program at the University of Wisconsin-Madison, like similar programs around the nation, was modeled after the Emerging Scholars Programs developed by Dr. Uri Triesman and his colleagues. The Wisconsin Emerging Scholars (WES) program was designed to boost the performance and persistence of freshman in UW-Madison's 3-course calculus sequence—a "gateway" course required of students planning to major in science, mathematics, or engineering. The WES program places students into special discussion sections where difficult worksheets and student-driven group work allow students to discover the principles and techniques of problem-solving through close collaboration with their peers. In the pilot year of the WES program (1993-94), half of the students enrolled in this program were women, 40% were from underrepresented ethnic minorities, and 30% were from small rural schools. This pilot group completed the first two semesters of calculus with grade point averages that were half a grade point higher than those of students in regular discussion sections, even when measures of precollege mathematical ability were statistically controlled. Compared with students in traditional discussion sections, the WES students also showed higher levels of confidence in their mathematical ability, greater comfort in performing calculus problems, and learned to value multiple and creative ways of problem solving, many of which they had learned from their peers.

The packet of dissemination materials regarding this reform contained the following:

- *A community approach to learning calculus: Fostering success for underrepresented ethnic minorities in an emerging scholars program*, a scholarly article for The Journal of Women and Minorities in Science and Engineering by LEAD researchers that focuses on the experiences of ethnic minority participants in the Wisconsin Emerging Scholars program.
- *Final Report on the Wisconsin Emerging Scholars Program*, a LEAD Center evaluation report on the WES calculus reform project.
- *Evaluation of the Pilot Wisconsin Emerging Scholars Program: 1993-94*, audiocassettes and a corresponding script produced by the LEAD Center that make use of student narratives to describe the impact of the WES calculus reform project.

2.2.3. Active and Interactive Teaching Techniques (from PROPMT)

This minicourse was organized by Humboldt State University Mathematics Professors Phyllis Chinn and Dale Oliver, founders of a mathematics reform group called Professors Rethinking

Options in Mathematics for Prospective Teachers. This group consists of college-level math instructors who have attended one of Dr. Chinn and Dr. Oliver's week-long workshops on group learning techniques. PROMPT members keep in touch and exchange ideas through a newsletter, conference get-togethers, and a website, all of which provide access to a community of supportive peers interested in math reform. This MAA minicourse was a short version of the usual PROMPT workshop. Minicourse participants engaged in a series of hands-on exercises illustrating ways to engage students in learning mathematics actively. The participants worked through the same exercises that their students eventually might, using the same worksheets and learning tools, while Dr. Chinn and Dr. Oliver modeled the instructor's role of classroom facilitator. The mathematics included ideas from geometry, logic, group theory and discrete mathematics. Techniques modeled included two-person interactive games to illustrate mathematics concepts, formal groups-of-four logic activities to motivate collaborative learning, and manipulative-based investigations to enhance mathematical understanding. In both their workshops and this minicourse, Dr. Chinn and Dr. demonstrated reforms which have proved successful in their own courses but that were developed by other reformers whom they cited.

The dissemination materials for this reform were distributed during the minicourse and included student worksheets for the group learning activities demonstrated during the minicourse; how-to handouts on various exercises written by Dr. Chinn; a 4-page handout extending upon the ideas discussed during the minicourse; and a list of references to on-line sources for more ideas, including the PROMPT webpage (www.humboldt.edu/~prompt). Participants were also given the opportunity to look through the manuals and workbooks from which the worksheets and exercises had been gathered.

2.2.4. Technology, Modeling, and Cooperative Learning

This minicourse was organized by Mathematics Professor Jim Sandefur and Rosalie Dance of Georgetown University, but only Dr. Sandefur was able to attend. Participants worked in small groups on investigations that provided a context through which to teach topics in college algebra and precalculus. Using inexpensive materials, the groups learned how to make a physical model to simulate a situation, and then interacted with the model and their group members to develop a corresponding mathematical model which described the behavior of objects in the physical model. Finally, their mathematical models were analyzed using algebraic techniques and graphing calculators. The physical models used included: the buildup of drugs in the bloodstream, the speed of light through water, and the area of "infinite" spirals and fractals. The participants experienced the same activities their students would experience, using the same worksheets and learning tools, while Dr. Sandefur acted as classroom facilitator.

The dissemination materials for this reform were distributed during the minicourse and consisted of six 2- to 14-page handouts written by Jim Sandefur and Rosalie Dance, which described in detail how to utilize each physical modeling exercise developed for this reform. The handouts explained the mathematical principles behind the models and the pedagogical principles behind each stage of the learning activity, took instructors through each exercise step-by-step, and discussed the various difficulties that students may encounter during each exercise.

2.3 The target population and the interviewed sample

The target population for our dissemination study was chemistry and mathematics instructors (preferably tenure-track faculty members) at large to mid-sized, four-year, Ph.D.-granting institutions. Originally we hoped to restrict the study to faculty members at institutions with a Research I or Research II Carnegie classification, but the number of such faculty members reached by our four dissemination approaches was not large enough, so some faculty members at smaller Ph.D.-granting institutions were also included.

Because participants self-selected for three of the four approaches, the number of instructors who were subject to each approach varied widely, and not all of them were from the desired target population. In all:

- 50 chemists and mathematicians (25 each) were mailed unsolicited packets for Approach A. All of these instructors were from the target population.
- 50 mathematicians ordered packets from a math website for Approach B. About a quarter of these instructors were from the target population. In addition, 51 more ordered packets through a paper version of the NCTM bulletin, but less than a tenth of these were from the target population
- 13 chemists who attended Art Ellis's presentations were sent related materials for Approach C, and all of these were from the target population.
- 37 mathematicians enrolled in the two MAA minicourses for Approach D. About a quarter of these were from the target population.

The names and addresses of the instructors subject to each approach were kept on file. About one month after instructors had received the dissemination materials, those who belonged to the target population were sent a letter which described our study, explained its goals, and asked for their participation in interviews. These same instructors were then called a week later, reminded of the letter, and asked if they wanted to schedule a phone interview. Those who agreed to be interviewed were called back at a time that was convenient to them.

Many of the professors we attempted to contact for interviews could not be reached during the time of our study. Of those that were reached, several declined to be interviewed or were unavailable during the interview time they scheduled. A few professors who had been interviewed became concerned about their privacy and later asked that their interviews not be used. A few others had to cut their interviews short and were not able to be asked critical questions. For these reasons, only 30 interviews from the target population were completed and available for analysis at the end of our study period. The sample populations interviewed for each dissemination approach are described below.

For Approach A, unsolicited mailings, there were 11 usable interviews, 5 from chemists and 6 from mathematicians. All but one of the interviewees were male, and all but two were tenure-track professors. The 9 tenured faculty had 14 to 33 years experience in their current positions. Seven were already involved in reform efforts at their schools, while one was very active in opposing reform efforts.

For Approach B, mathematics websites/NCTM Bulletin, there were 7 usable interviews, 5 from the mathematics websites, and 2 from the paper version of the NCTM News Bulletin. All were male tenure-track professors with 3 to 31 years at their current positions. All of those who accessed the announcement through a website said they use the Internet daily. Three were already doing a WES-like reform and were just curious about how other programs compared, while two were considering a WES-like reform and were shopping for ideas on how to do it.

For Approach C, 1-hour presentations, there were 6 usable interviews, 4 from Iowa State and 2 from Florida State. These 5 men and 1 woman were all tenure-track chemistry professors with 7 to 27 years at their current positions. Five were already involved in reform efforts at their own universities, and two had been actively involved in bringing Dr. Ellis to speak at their campus. All of the interviewees belonged to departments that were committed to doing some type of reform but which were still shopping for ideas, and MEGC was one of the reforms their departments were considering.

For Approach D, MAA minicourses, there were 6 usable interviews, 4 from Phyllis Chinn and Dale Oliver's minicourse and 2 from Jim Sandefur and Rosalie Dance's minicourse. All but one of the interviewees were male, and all were tenure-track mathematics professors with 2 to 12 years in their current positions. All of them were involved in reform efforts at their own universities and all were from departments or universities that placed a fairly strong emphasis on teaching.

2.4. The interviews

The semi-structured, open-ended phone interviews took 15 minutes to just over an hour to complete and were conducted by three LEAD researchers working from the same set of interview protocols. Each dissemination approach and each packet of materials had its own set of questions regarding that particular approach or packet, but the *types* of questions on each protocol were very similar. In all, there were 7 different interview protocols, with every protocol containing questions about the following:

- Background information on the interviewee's position, their years at that university, and what courses they teach.
- The interviewee's teaching philosophy and how they approach the teaching of their introductory courses; whether and how they use groupwork or in-class demonstrations; what their experiences with various reform activities have been.
- Whether they skimmed or read any of the dissemination materials they received and what their reactions were to each of these materials; what factors prompted them to read or not read the materials.
- What they thought of the reform discussed and whether they were planning on incorporating any of its activities into their own courses; what factors prompted them to consider or not consider trying the reform.
- What they thought of the dissemination approach and its effectiveness in getting them to consider using the reform; how they prefer to be informed about educational reforms and why.

- How open their departments were to reform efforts and how many of their colleagues were involved or interested in reforms.
- Institutional barriers and incentives for reform in their department.

3. The major findings

The 30 interviews were analyzed approach-by-approach and then across approaches in order to uncover recurring patterns and themes and assess the effectiveness of each dissemination approach. In the sections that follow, we summarize the major findings that emerged from this inductive qualitative analysis.

3.1. The effectiveness of a given dissemination approach depends on what "stage" a potential user is at in their willingness to try a reform.

Past research has shown that the dissemination and utilization process has several stages, of which adoption is the first. Our analysis of interviews from the current study suggests that the decision to adopt a reform has several stages in and of itself, and that disseminators of educational reforms must be prepared to take their prospective users through these three stages before changes in behavior actually occur. The stages of the adoption process that emerged from our analysis were:

1) Exposing potential users to a reform: This is what gets people initially interested in a reform and makes them curious to hear more about it. Exposure is usually accomplished through word-of-mouth about the reform or the reformer, casual browsing of the research literature, or interpersonal connections with a reformer.

2) Informing potential users about the reform: This is what gives people the basics about how a reform works and presents evidence that the reform is both needed and effective. Potential users must generally make an active choice to become more informed, and they typically gain this basic information through conference presentations, local seminars, research articles, and downloading material from websites.

3) Teaching potential users how to implement the reform: Most potential users will invest the time in learning *how* to use a reform only after they are fairly certain that the reform is worthwhile. Even then, many people will not fully commit to a reform until the "teaching" stage, during which disseminators give hands-on instruction in how to use the reform and potential users get the opportunity to see whether the reform is "workable" for them.

Only a small percentage of those who are subject to dissemination approaches will choose to pursue a given reform, and at which of the above stages the commitment to adopting a reform actually occurs will differ depending on the user. Some users will be convinced early on, but others will have to proceed through all three stages before they decide that a given approach is truly worth their while. The point made clear by our analysis is that no given dissemination approach is always superior or always inferior to other approaches. Rather, different dissemination approaches play different roles in the adoption process, with a given dissemination

approach being stronger or weaker depending on what stage the user is in. As a result, effective dissemination is often a process of catching users at the right time with the right dissemination approach, one that is neither too detailed nor too abstract for the user's current level of interest and understanding. This ideal match between a learner's readiness and the complexity of the concept to be learned is similar to what Vygotsky (1978) called "the zone of proximal development." According to Vygotsky, teaching practices are most effective when they teach concepts that are *just beyond* a learner's current level of understanding—close enough so that the concept may be grasped once the learner is given a "boost" from the outside, but not so close that the concept is uninteresting because it seems too similar to what the learner already knows.

In the current study, it seems more appropriate to refer to this moment in a potential user's development as *the reachable moment*—the moment at which a potential user is ready to try something new but isn't quite sure how to go about it yet. Our research found that sending out unsolicited packets for Approach A caught people at very different degrees of openness to reform and very different stages in the adoption process. About a quarter of the interviewees who received these packets got them "too early" for them to be effective in behavior change, either because the users hadn't yet developed an interest in reform or because they were not willing to take the time to look at a reform they had never heard about. (In advertiser's terms, we would say the reform had no "brand name recognition" with this group). For these people, the most the packets could accomplish was exposure, and according to the interviewees, this means of exposure was not quite as effective as hearing about the reform from a colleague. Meanwhile, for about half of the interviewees in Approach A, the packets came "too late" in that the users were already participating in reform efforts of their own. Sometimes it was a reform similar to the one mentioned in the packet; other times it was something different. In either case, there was little inclination for them to give more than a cursory look to the dissemination materials we sent. Those that did look through the materials did so because they were curious how the reform compared to one they were already trying, but they had no interest in acting on anything the packet said. Generally speaking, once users moved into the implementation stage for one reform, they no longer had the time or the desire to consider other reforms.

Across all the dissemination approaches, the only interviewees who were open to being persuaded by the dissemination materials were those who were already interested in or committed to the need for a reform but who were shopping around for the right approach—in other words, those who were at the "reachable moment." It should come as no surprise that we were more successful catching people at a reachable moment when they were able to self-select for a dissemination approach, as was the case with Approaches B, C, and D. All of these approaches let potential reformers seek information about a reform on their own and allowed them to select the level of detail best suited to their needs. In Approach B, instructors ordered dissemination packets from a website, suggesting they had at least some interest in hearing more about the reform we had described. All five interviewees who ordered WES materials from a math-related website read or glanced through the written materials we sent them, though none listened to the tapes. Three of these interviewees were already doing a WES-like reform and were just curious about how other programs compared, while two were considering WES-like reforms and were shopping for ideas on how to do it. These latter two interviewees were at the reachable moment, while the other three were already beyond it. Among our 30 interviewees, the number of

potential users "reached" by Approach A and Approach B was the same (2 for each approach), but Approach B was more efficient in one respect because it was more effective at targeting people who had a pre-existing interest in reform. On the other hand, Approach B may be less efficient in other respects—for example, if the disseminator wants to control the number of packets sent to non-research-university professors. Which approach is preferable depends on who the disseminator wants to reach, and how important it is to be efficient at reaching them. If money is a concern and a disseminator wants to cut down on the number of free packets that get thrown away, it is best to let potential users order the packets for themselves, as in Approach B. Alternatively, if a disseminator wants only certain types of professors to receive free materials, the disseminator must select the recipients, as in Approach A Also, if one can afford to have a large number of packets left unread, sending out unsolicited packets may reach people who haven't yet been exposed to or informed about a given reform. In a small percentage of cases, unsolicited mailings can and do attract people who would not know about a reform otherwise.

Still, when efficiency matters, either to the disseminator or to the potential user, it is best to use a dissemination approach that is both interactive and readily accessible. The one-hour seminars given by Art Ellis for Approach C had both of these features and proved very effective at getting interviewees to consider trying his reform. One reason for this approach's effectiveness was that the talks were organized by professors who were already committed to reforming their department's introductory chemistry courses and were shopping for ideas on how to go about it. However, the meetings were also attended by people who had little or no pre-existing interest in reform. So in some cases these relatively brief talks did an effective job of informing professors at a "reachable moment" about MEGC, and in other cases the talks gave people initial exposure to the reform. According to our six Approach C interviewees, Dr. Ellis's talk consistently left more of an impression than any of the MEGC dissemination materials they received in the months that followed. All but one of the interviewees said they merely thumbed through the MEGC materials or didn't look at them at all. Hence, most of the interviewees' opinions about the reform were based on what they heard, not on what they read.

Without exception, the interviewees found Dr. Ellis to be an engaging speaker and found his live demonstrations and handling of their questions very persuasive. Four were even prompted to seek more information afterwards, but they generally acquired this information through interpersonal channels. People who wanted additional information could and did occasionally turn to the written materials we sent, but rarely did more than skim them. Many interviewees said they would rather hear about a reform from a colleague's talk than read about it because attending talks is more engaging and less time-consuming than sitting down to read an article. Whether the talk is a 15-minute conference presentation or a one-hour local seminar given by a visiting professor, the extra time commitment on the part of a faculty member is small, because attending either type of talk is already a regular and expected part of their routine. Reading articles is *also* a regular part of their routine, but most faculty members only make time for articles that apply directly to their research. The only interviewees who preferred to read about reforms were the two non tenure-track instructors we talked to, neither of whom had the incentive or the money to attend many research conferences.

Our study found that Approach D, the MAA minicourses, did best at catering to the needs of people in the final stage of the adoption process. Although the minicourses also served the purpose of informing a few people who knew little about those particular reforms beforehand,

they were generally attended by people who were firmly committed to reform and had already tried group work in at least one of their courses. The Approach D interviewees thought it was unlikely that many professors who had never heard of a given reform or who had never considered the need for such a reform would be willing to sign up for something as long and intensive as a minicourse. In short, minicourses are better suited to people who want to be taught how to use a reform than to people who have yet to be informed about it or even exposed to it. Both minicourses we observed did a good job of providing details on exactly how to implement a reform to those who were already fairly interested in trying it, although many of them wished for an even longer workshop. For those who had already decided to adopt the reform, the four-hour minicourses were too short to provide all the examples and training than the users desired. On the other hand, for those who had not yet committed to adopting the reform, the length of the minicourses was just right and allowed them to get enough hands-on experience with the reform to make an informed decision about it. Two of the four interviewees who attended Chinn and Oliver's minicourse said they would be interested in attending one of the week-long PROMPT sessions in order to get more intensive training. One of these had been fairly committed to adopting the reform before the minicourse (because she was already fairly familiar with Dr. Chinn's work), while the other made the decision to adopt during the minicourse. One of the two interviewees who attended Sandefur and Dance's minicourse became interested in adopting the reform during that minicourse but said he would get any additional information he needed through interpersonal contacts with Dr. Sandefur.

In the final analysis, more interactive dissemination approaches like talks and minicourses were more likely to engage people's attention and nudge them toward considering a reform; however, each form of dissemination had its pros and cons. Many of the respondents who had only read about a reform (Approach A or B) spoke of the shortcomings of this dissemination approach, and said that most of their colleagues would not even consider a reform until they had the chance to discuss it in detail with someone who had actually tried it. Indeed, the importance of personal contact with reformers and getting clear examples of how a reform works was stressed by interviewees from all four approaches. The most interactive dissemination approach, hands-on minicourses, was so effective because it gave potential users the opportunity to interact with reformers, peruse materials used in the reform, *and* be taken step-by-step through the exercises. On the other hand, the minicourses were too much of a commitment to attract people who were not already interested in the reforms. Reformers and attendees alike worried that the minicourses were "preaching to the choir." Less intensive and more accessible dissemination approaches like mailing out research articles, posting on websites, or giving talks were considered more likely to "get people through the church door" in the first place. In short, each dissemination approach we studied had its time and place in the gradual process of persuading professors to try something new.

3.2. The reputation of a reformer or the reputation of the institution disseminating a reform can have a powerful influence on the successful dissemination of that reform.

Another theme that consistently emerged from our interviews is that having an esteemed researcher or institution backing a reform goes a long way in drawing people's attention to the reform and convincing them that it is worth their while. In some ways, it is like having a celebrity endorse your

product. Interviewees made it clear that faculty members are unlikely to pay much mind to someone who they don't know or don't respect, and in a field cluttered with reform options—"95% of which are bunk," according to one interviewee—anything disseminators can do to give their reform a boost in credibility is important. A number of the chemists we interviewed said that Art Ellis's reputation as a researcher who is *also* a talented and committed teacher went a long way in winning their attention to his reform. Others said that the UW-Madison's reputation as a "hotbed" for chemistry reform or their knowledge of other reforms by UW's John Moore and the Institute for Chemical Education are what prompted them to at least skim through the materials we sent them. If the packet had come from a less-esteemed or less research-focused institution, they said they probably would have just thrown it away. Hence, a reformer's reputation can be critical to successful dissemination during the exposure stage, and it can also boost a reform's credibility and perceived usefulness during the informing stage.

While having a good reputation is *part* of what makes a reformer or disseminator credible, it also helps when the reformer or disseminator is considered a "colleague"—someone with a similar background and similar concerns. Interviewees said academics can be very insular and will generally only listen to academics who are "just like them." This means a reformer will be the most persuasive when he is from a similar type of institution and in a similar research area as the professors he is trying to persuade. A number of interviewees mentioned the "educational researcher/practitioner split" that makes it difficult for teachers to take instruction or advice from educational researchers who no longer spend time in the classroom. Others mentioned a similar split between professors at large research institutions and those at smaller universities and colleges that place a greater emphasis on teaching. The interviewees made it clear that some research university professors are totally unimpressed by the research or methods of scholars at smaller or less-esteemed institutions and have no inclination to pay attention to anything they say, especially when it comes to teaching. Others argue, "I don't care if group work worked for them. They have 20 students in their class. I have 200!" As this statement shows, part of the problem is that professor believe that certain reforms, developed for use in small classes, do not work in the same way, if at all, when transferred to large classes. What's more, even when research university professors teach small courses, they often have much less time to work on their teaching or devote to revamping a course than do their counterparts at non-research universities. So even when university professors are respectful of and impressed by the reform efforts of instructors at smaller schools, they are often skeptical that what worked for those instructors will work for them. By contrast, when they hear that someone like Art Ellis, an esteemed researcher in his own right, uses a reform like MEGC in his large introductory classes at a major research institution, they are more likely to believe that they can do it too.

A final and related point under this theme is that personal contact with reformers or with the disseminators of a reform is helpful in encouraging that reform's spread. About half of interviewees for Approaches A and B mentioned that receiving or ordering materials by mail was a very "impersonal" way of learning about a reform and that they would be more likely to read the packet of materials is they knew the disseminator or the reformer who sent them. Of course, "knowing" takes many forms. Sometimes knowing a reformer or disseminator is as simple as having met them at a conference or having had a phone conversation with them. Other times, faculty members won't take time to read non-research-related materials unless the reformer or

disseminator is a personal friend. In any case, the best way to move a dissemination packet to the top of someone's reading pile is to have some form of personal contact with them, even if that means just calling them by phone to give them some background on the reform. About half of the interviewees who eventually read the packets said they did so only after we called them to schedule an interview, and noted that the packet plus the call was a far more effective dissemination method than the packet alone. Although many of these faculty members had the materials on file and said they were planning on reading them "eventually," some admitted they couldn't manage to find the time until suddenly faced with the prospect of being asked questions about articles they hadn't read yet.

3.3. There was a wide range of reactions to the materials we sent and the two reforms they discussed.

3.3.1. Professors' impressions of the dissemination materials

Our analysis of interviews uncovered a wide range of outcomes and opinions regarding the packets of materials we sent. Of the 24 interviewees who received dissemination materials about WES or MEGC, one didn't read past the cover letter and had since discarded the materials, 11 set them aside or put them on file (and 7 still hadn't read them by the time they were interviewed), 6 skimmed through them before they knew they were in a study, and 6 read all of parts of the materials before they knew they were in a study. In sum, the materials we sent were examined by almost two-thirds of the professors we interviewed. However, this percentage is probably higher than the percentage of all the professors who received the materials who read them, due to both a "researcher effect"—the fact that three of the interviewees didn't read the materials until they knew they were being studied—and an interview "self-selection effect"—the fact that the handful of professors who refused to be interviewed generally did so because they hadn't looked at the materials. For this reason, our interviewed sample of professors may be a "biased" one, with a higher percentage of willing readers than would have been the case in the general population of research professors. Similar problems with the researcher effect and self-selection plague much of applied research, limiting the conclusions that can be drawn from such numbers.

Audiotapes were not found to be an effective dissemination method in the current study. None of the 13 research professors who received audiotapes about the WES program listened to them. Many interviewees said listening to the tapes would be too difficult and time-consuming because they didn't have a tape player handy and the tapes weren't amenable to "skimming." Also, according to one interviewee, the tapes "had the flavor of advertising, which in general turns me off." On the other hand, a few interviewees said they liked the *idea* of using tapes as a dissemination medium, even though they never got around to listening to them.

Of the 19 interviewees who had something to say about the dissemination materials we sent (4 of whom didn't read past the cover letter), 2 were not impressed with the presentation or the evidence (one of whom was already very hostile toward reform in general), 5 thought the ideas were good but didn't see how the reform would apply to their own courses or needs, 7 were considering incorporating some aspects of the reform in their courses, and 5 were already doing a similar reform (the Emerging Scholars Program or something very like it). Hence, over a third of

the professors who had an opinion on the materials were persuaded by what they read, and about a quarter didn't need persuading because they were already implementing the reform when our materials reached them. But again, firm conclusions cannot be drawn from these numbers since this sample may not be representative of the population of research professors as a whole.

So what did professors have to say about the length, form, and accessibility of the dissemination materials we sent? The vast majority said that the packets contained too much information, more than they would ever have time to read, which is why most only skimmed them or read parts. For the MEGC packet, the journal article was 7 pages and the booklet on the history and the evaluation of the reform was 74 pages. For the WES packet, the journal article was 15 pages and the evaluation report was 73 pages (plus 19 pages of Appendices), while the script accompanying the audiotapes was 37 pages. Most interviewees wanted the materials shorter and "punchier," particularly the evaluation report, which three interviewees described as "intimidating" in its length. One interviewee found the booklet on the history of MEGC "a little self-serving," but a more reform-minded interviewee from the same department was very interested in the history and development of the reform. One interviewee really liked the student-perspective quotes included in the WES article and the WES evaluation report (one reason why it was so lengthy) and found the quotes "more convincing than the stats you included," while another felt the materials' early focus on student perspectives rather than student performance was "off-putting" and said it kept him from reading further. Some interviewees wanted more concrete examples of materials used in the student exercises and instructions on how the exercises are run. These interviewees tended to be at the stage where they were ready to be taught how to implement the reform, and neither packet provided enough details of this sort. Clearly, the packets were best suited to people who had already been exposed to reform concepts but were looking for more information about how and whether this particular reform works. People who were past these stages and ready for implementation instruction would have been better served by a minicourse, a workshop, or a how-to manual.

3.3.2. Professors' impressions of the four reforms

Wisconsin Emerging Scholars program: Our interviews found that the concepts from Emerging Scholars Programs like WES are gaining wide acceptance and are already being used by a number of universities included in our sample. Those professors and institutions that weren't currently implementing or planning to implement an Emerging Scholars Program were under the impression the program was just for minorities. Although it is true that the WES program was originally conceived as a program for "at risk" calculus students—which included women, students from small towns, *and* racial minorities—and although the article included in the WES packet focused on how the program impacted minority students, the principles of the WES reform can be applied to any student population. This reform places students into special discussion sections where difficult worksheets and student-driven group work allow students to discover the principles and techniques of problem-solving through close collaboration with their peers. This is something which would benefit many calculus students, regardless of their background. Nevertheless, interviewees who paid little mind to the WES dissemination materials generally felt that, because of the reform's perceived restriction to minorities or "at risk" students, the reform was not relevant to their own institutions' needs. Some stated that they didn't have enough minorities to

make the program worth the while, while others felt quite strongly that they shouldn't cater to less-capable or less-dedicated students with a special program. A few interviewees, even some who were involved in establishing Emerging Scholars Programs at their own schools, argued that the reason ESPs work is that they "force students to do their homework, so of course they're going to do better." According to this argument, a simple increase in time-on-task is what produces the increase in student performance seen with ESPs. While this may be part of what produces the program's benefits, the data we provided on the WES program suggested that the program also prompts students to think more creatively and flexibly when solving calculus problems, gives them a richer and more explicit understanding of calculus concepts, gives them an appreciation for working in teams, and creates a sense of community at large universities. Some interviewees recognized these other benefits, but many did not. A few were informed of them only after reading our report.

Materials Enriched General Chemistry: Most of the professors we interviewed about the MEGC reform thought Dr. Ellis had some interesting ideas, especially the more general ones about teaching and making lectures more interactive. However, almost everyone was turned off by the reform's focus on materials science. Those who perceived the reform as too closely tied to materials science believed the information in the packet was irrelevant or of no use to them. Most wondered why they should use materials science to teach these concepts if they could do it using things from their own research area. Their hesitance in adopting something like MEGC had to do not only with their and their T.A.'s lack of familiarity with materials chemistry (Art Ellis's specialty), but their desire to protect and promote their own branch of chemistry research. As one interviewee put it: "[MEGC] is fine for someone who has a materials science focus… However, I think for someone who is not materials-science oriented, there are other ways to achieve teaching the same principles. I myself would not take that approach." Those chemists who were considering using some aspects of MEGC had decided to drop its emphasis on materials science but adopt its interactive teaching techniques. The lone exception was an interviewee who chose to do the exact opposite. This professor actually *liked* the emphasis on materials science, which he said "has long been neglected in chemistry," and he was planning on incorporating a number of Dr. Ellis's materials science demonstrations into his lectures. However, this professor did not plan to change the traditional lecture format of his class in any way. His objective in "adopting" MEGC was to enliven and expand the relevance of some of his lectures by incorporating interesting materials science demonstrations, but he did not intend to make any significant replacements or adjustments in the structure of his course or the nature of his lectures (the pedagogical heart of MEGC). As he put it, "I regard this not so much as a different approach to teaching sciences, but as sort of a different curriculum that is introducing new subject matter into chemistry." On a final note, one professor mentioned that having a corresponding textbook with MEGC would eliminate a lot of the barriers to using it.

Active and Interactive Teaching Techniques: Because the majority of participants in Phyllis Chinn and Dale Oliver's minicourse were already familiar with group work and had contemplated using exercises like theirs for some time, this group of interviewees was more receptive to the reform than interviewees from the other three dissemination approaches. In the interviews we did with this group, most talked about being inspired by seeing so many other math instructors like them who were interested in using interactive teaching techniques, and about feeling somewhat isolated

in their own departments. They said the workshop gave them a sense of community with other reformers. All of the interviewees perceived the minicourse as an opportunity to network and forge connections that would last beyond the conference. One perceived what he learned during the minicourse as validation of the teaching techniques he had been developing on his own and realized that to some extent he had been "reinventing the wheel." Only one interviewee had a negative reaction to the reform itself. This individual said it was unlikely he would use any of the exercises or techniques they demonstrated because he simply didn't have enough time. "If I want to make a student understand the concept of function with the tricks that they were teaching," he said, "I'll never get through all the material in the ten weeks that I have…My students after they finish with me go to the next teacher, and the next teacher expects them to know something, so I should finish the concept. If I want to stand there and play games, it takes a whole week to go through the finishing of the function. I was looking for something more efficient."

Technology, Modeling, and Cooperative Learning: As with the other Approach D interviewees, the interviewees who attended Jim Sandefur and Rosalie Dance's minicourse had somewhat more to say about the workings of the minicourse than about the reform itself. The two people we interviewed were both very impressed with Dr. Sandefur's manner and presentation and found the exercises he demonstrated to be very interesting and engaging. There was some concern as to how readily they could get the modeling materials they needed and how long it might take to set up for such exercises. They also wondered how the "messiness" of the exercises—in that things in a live demonstration don't always turn out the way you want—would affect efficiency with which a concept could be taught. Both interviewees really enjoyed the minicourse, but only one was fairly certain he would employ any of the demonstrations in his own courses. This interviewee said that the exercises were at a somewhat higher level of cognitive development than the exercises he typically gives his students and that it would be "very challenging" for them, but he thought he'd give one or two of the exercises a try. The other interviewee felt he would probably make up exercises of his own rather than use the ones Dr. Sandefur had demonstrated because, "I guess I'm at a stage in my career where I like to do my own thing more." Both enjoyed meeting other people at the minicourse and said they'd feel comfortable contacting Dr. Sandefur at some later point if they had questions about implementing his reform, but neither emphasized a feeling of community in the way that attendees of the Chinn and Oliver minicourse had.

3.4. Professors who choose to engage in reform efforts do so because of a perceived student need and a personal and altruistic commitment to serving those needs.

Interviewees who were considering or who were already engaged in reforms were asked about their reasons for doing so. Many interviewees also described the personalities and motivations of other reformers they knew. An analysis of these responses suggested that, in the vast majority of cases, professors who choose to engage in reform do so because of a perceived student need and their own personal or altruistic commitments to serving those needs. What professors had to say about the need and motivation for reform efforts is summarized in the three sections that follow.

3.4.1. Who typical reformers are

What is the typical profile of a professor who chooses to initiate a reform? Such professors tend to be very enthusiastic about their field and want their students to enjoy it as much as they do. They are generally energetic and optimistic, turned on by life in general. A number of those we interviewed said they get a kick out of seeing their students realize their potential. These professors were committed to their students' advancement and intellectual development and "admitted" they like their students and want to teach them in ways that will serve them best in the world they will face after graduation. Professors who initiate a reform effort must be willing to take risks and work hard. They must be willing to make multiple adjustments to the reform effort as they go, and must recognize that not everything will work with every group of students, especially the first time. Reform initiators tend to be engaging and animated in front of a class. They can be young or old, tenured faculty or non-tenure-track instructors. Reformers are more readily identified by their commitment to their students than by their stature in their department.

At the same time, a number of interviewees told stories that supported Kozma's (1985) theory that a reform is more likely to succeed when there is group investment rather than individual investment in the reform. While reforms need at least one enthusiastic and committed person to get the reform effort off the ground, it takes more than one individual to institutionalize a reform and give it permanence. Ideally, an entire group is involved in the initial adoption of the reform, as was the case with the faculty committees at Iowa State and Florida State who went "shopping" for a reform to be used by all of their general chemistry instructors. This does not mean a reform cannot be successful if the idea starts with one individual, but if a reform is to last beyond the person who started it, that person needs to recruit equally enthusiastic and committed colleagues to try it for themselves or take up the reins when it comes time for "handoff." One professor who had been nominally involved in a WES-like reform at his university told the sad story of that reform's "dwindling away" after the professor who had started it was forced to take a medical leave. "To be totally honest about it," this professor admitted, "it was her project, and as long as she was here, she was really committed to it in a way that no one else was. I guess that's something to think about for any program, to be sure that it transcends the individual." This statement perfectly encapsulates what Kozma (1985) found.

Interviewees were also asked whether having tenure affects the likelihood of one's participation in reform. Most thought tenure had no effect, or that the effect of having "intellectual freedom" was negated by the fact that some professors are too set in their ways and reluctant to change by the time they get tenure. Many thought, if anything, that the younger instructors were more open to reform, especially those who weren't even on the tenure track and hence placed a greater emphasis on their teaching. But a few who were interviewed thought tenure definitely *did* have an effect because it allows professors the freedom to "work on whatever they like" and not be "hounded by their departments about producing more research."

Most interviewees said that for a long time professors in their and other departments who have put time and effort into their teaching have been seen as second-class citizens. As one interviewee said, "It's almost a negative at the promotion/tenure time when someone says, "He is a good teacher." However, several interviewees noted that the "old guard" at their school was retiring—which in some cases included the department chair—and, as a result, their departments were becoming more open to reform. Several also felt that the tide at other universities is finally

changing, and that, thanks in part to the NSF's increased emphasis on educational reform, caring about one's teaching is becoming more respectable.

3.4.2. The typical "story" of a reform: Why it is undertaken and how it proceeds

What *compels* instructors or departments to try a reform? Those who had been involved in reforms at their own university often told a similar tale. The tale for those involved in WES-like reforms goes like this: Too many students are failing or dropping out of a course that is already geared toward remediation. The department chair doesn't know what to do and asks one or two energetic and concerned instructors (at least one of whom is a senior faculty member) to work on revamping the course as a "favor" to the chair and the department. The faculty "volunteers" are typically given release time or other compensation for their efforts. One of the faculty members hears about Uri Triesman's Emerging Scholars Program through a talk given by Treisman or through colleagues on campus who are already trying it in their department. The faculty members decide to try something similar with the problem course. Their version of the program is quite successful in terms of increased student attendance and performance (in some cases these students even outperform those in standard recitation sections), but the program has a hard time recruiting sufficient numbers of students to participate or the reformer has a hard time convincing colleagues that the program's positive evaluation is valid. The reformers dedicate themselves to working on these problems in subsequent semesters. However, if a major player in the reform drops out, there may be no one left who wants to take on the heavy workload this person had shouldered, and the reform dwindles away.

3.4.3. What professors hope to accomplish in pursuing a reform

When interviewees were asked what they hoped to accomplish in pursuing a reform and how they would measure "success" at accomplishing those goals, the interviews said the following: The reform should boost students' performance on exams and cause a reduction in the drop rate for the course. It should make the instruction of students more interactive so that it is more engaging for students and teachers alike. A few interviewees said that lecturing to a room of blank stares is both boring and unfulfilling and said that just having students who seemed "more awake and more enthusiastic" would make the reform worthwhile. Prospective reformers hoped to encourage their students to understand underlying concepts and to give them the ability to apply the lessons learned to new contexts. They thought such learning would be measurable through the written exams and written research projects which some interviewees were being asked or required to incorporate into their courses. Those teaching general education courses said they merely hoped improve their students' ability to think clearly and critically about the things they read regarding science and technology. They thought this could be measured through how clearly students express their opinions and understandings in writing and in conversations.

3.5. There are numerous disincentives and barriers to reform, some at the personal level and some at the institutional level.

Our interview analysis found there were also numerous disincentives and barriers to reform. Some interviewees spoke of their own disincentives to implementing reforms, while others expressed the arguments against reform that they had heard from colleagues. The most frequently mentioned barriers to reform are summarized in the sections that follow.

3.5.1. Doubts whether reform is really necessary

One early barrier to reform is that some professors doubt whether reform of their teaching practices is even necessary. These professors often believe that the problem lies not with their teaching methods but with the students themselves, who are seen as lazier and less-focused than students in previous generations. Such professors believe that it is the students who should change, not the teacher or the curriculum. Some question whether reforms would even be necessary if students just did their homework. These professors argue that most reforms involve "spoon feeding" students and that group work in particular allows students to "mooch off of smarter students" and otherwise avoid the "real work" that they are unable or unwilling to do themselves. Interviewees who expressed this opinion believed that departments should not do anything to "coddle" students with poor study habits.

3.5.2. Perceived lack of evidence that the reform is more effective than what they're doing already

Even those who saw a need for reform were often skeptical that the proposed reform would actually boost students' performance on exams. Many professors are reluctant to change the traditional teaching methods they are currently using until it can be "proven" that new approaches will boost student learning in their courses. For example, one interviewee who received an unsolicited WES packet was strongly opposed to reform efforts altogether and had worked to drum up opposition to reforms at his own university—reforms which he perceived as "spoon-feeding" with no research to support them. This interviewee argued that his own, very traditional teaching approach encourages students to be independent scholars and have better study habits, while the reform his colleagues were using caters to students' laziness and doesn't require them to do the thinking they need to do in order to actually learn something. This interviewee did not believe that the reforms that his department was "pushing" actually worked, and was angered that the department chair and other supporters of reform were "ignoring" evaluation results that seemed to suggest the reform wasn't as effective as traditional methods like his own. A number of interviewees who were trying reforms came up against similar skepticism at their institutions. Many of these reformers were struggling to find ways of evaluating their reforms that their colleagues would find "valid" and convincing. Some conceded that they may never be able to "prove" the effectiveness of their reforms due to the methodological difficulties of running a controlled experiment in an uncontrollable environment. Others suggested that no amount of evidence would convince those who don't want to be convinced because the cost of change is too high, a theory also advanced by Zaltman (1983) in his article on "knowledge disavowal." Part of

the problem, one interviewee argued, is that professors have difficulty overcoming their biases about "the best way to learn things," which, more often than not, is whatever way *they* learned.

3.5.3. Time constraints within the classroom: Will content be lost?

Even for those professors who are fairly convinced that a reform is effective in encouraging a deeper and more readily-applicable understanding of concepts, there are concerns about the difficulties of using the reform in their own classrooms. A number of interviewees expressed concerns about time constraints in their classroom and were worried that content might be lost if they took the time to incorporate group exercises or other reform activities in their course. A number of professors who recognized the need for reform had been searching for a reform method that would allow them to enrich their students' understanding without dropping some course content, but had yet to find such a method. Most reformers themselves will admit that their reform exercises take a lot of time and that a professor cannot hope to cover all the material that he or she once did. However, these reformers argue, it is better to give students a rich and complete understanding of a smaller number of critical concepts than to give them a shallow and quickly-forgotten understanding of a larger number of concepts, some of which students will never encounter again. What counts is not what students can regurgitate for a test during the semester but what they can remember for use well after the semester is over. And for such a result, teaching fewer concepts better is the means to success. Still, such arguments are not convincing to everyone. And even interviewees who said they *wanted* to use reforms like group work said they had concerns about the logistics of trying such activities with large lecture courses. A number who had tried group activities in large lectures had found the combination unworkable and said it produced no better results than the lecture methods they were already using.

3.5.4. Time constraints in professors' lives: Will time spent on this reform take too much time from one's research?

In addition to time constraints in the classroom, there are time constraints in professors' lives. Many of the university research professors we talked to were concerned that time spent on reform activities would take too much time from their research. How, they wondered, would such a trade-off be perceived by their colleagues or their department when it came time for tenure or salary review? Most figured, or knew from experience, that too much time spent on teaching would be frowned upon in a context where research and the publication thereof is everyone's top priority. Almost all of the research professors we interviewed said tenure decisions and other academic advancements in their department were still based upon research publications far more than on anything done in the classroom. As one department chair said in regards to reform efforts, "If you don't have tenure, you are told not to mess with any of this stuff. Publish and get grants, make a reputation in your field. You cannot take time out to do [reforms] unless you are a chemical educator and the department has agreed that publishing about [reforms] would count towards promotion and tenure." One woman we interviewed had exactly such an agreement: "In my particular case, having done a lot of science education, I got them to put in writing that they would count it towards my promotion. And they sort of forgot about it, but then I pulled out the letter and reminded them." Clearly, research professors have valid reasons to be concerned about how much time a reform effort will take. In many cases, professors measure their degree of

comfort with a proposed reform by the ever-ticking "tenure clock." About a third of the interviewees who were already involved in reforms said they felt lack of support from their departments and another third felt indifference from their departments. In both situations, the professors revamping a course had not received any reduction in their teaching or research loads.

3.5.5. Difficulties in selecting a reform: So many options, so little time

Ironically, one barrier to pursuing reform is that there are so many out there. Having so many options not only reduces the likelihood that a particular reform will be chosen, but it may also reduce the likelihood of *any* reform being chosen. According to several of our interviewees, selecting a reform from the plethora that are available is a time-consuming and intimidating task in-and-of-itself. Not only is it difficult to choose among the ones that work, but it is often difficult to even *tell* what works—"to sort the wheat from the chaff," as one interviewee put it. This may be the very reason that professors often turn to their friends and colleagues when seeking information on reform: They are less likely to be overwhelmed by the options available if they only talk to a few people, there is a chance that their colleague has already done all the background research for them, and they will be able to get information on the effectiveness of the reform from someone they already know and trust. Interviewees said they would appreciate anything that made their search for information more efficient and less confusing. Some were using word-of-mouth to "pare down" their searches and using colleagues' opinions to filter out reforms that were unworkable or ineffective. Others were using the Internet and reform-related websites to make their searches more convenient. All of the web-browsers we interviewed for Approach B lauded the "at-your-fingertips" convenience of the Internet and said that becoming versed in using it had made it so much easier for them to do research on a variety of topics, reform efforts included. As one frequent user put it, "Instead of going to the library or whatever, I just go to the Internet. I go to the library only if the Internet doesn't give me the information that I need. Especially if it regards other schools, and looking at calculus efforts or things like that, there is so much available on the Internet that I tend to just look there first…I find that I spend less time than I used to on questions like that." Of course, these interviewees also admitted that using the Internet can be "chaotic" until one learns where and how to look for information.

4. Conclusion: The process of becoming interested in a reform is often gradual and incremental. Different dissemination approaches may be needed to reach people at different points along the way.

Our study of how research university professors responded to four different dissemination approaches found that the process of becoming interested in a reform is often gradual and incremental. According to our analysis of professors' interviews, there are three different stages to encouraging someone to adopt a reform: exposing the potential user to the reform, informing the potential user about the reform, and teaching the potential user how to implement the reform. Successful disseminators of reform information must be prepared to take their potential users through all three of these stages. Our study also found that each stage favors different dissemination approaches. Since no one approach will work for every person at every stage of the adoption process, different approaches are needed to reach people at the different points along

the way. So although the more interactive dissemination approaches like talks and workshops were generally more effective at convincing research professors to give reforms a try—in part because more reform-minded professors self-selected into these approaches—such approaches are not ideal in every case. When the potential user is still in the earliest stages of the adoption process, something as intensive and information-packed as a minicourse may be far more than the user is ready for. On the other end of the spectrum, when a potential user is at the stage where he or she is trying to figure out how to implement a reform, the information provided by a journal article or a one-hour talk might not be enough to satisfy the user's needs. In short, effective dissemination seems to be a process of catching users at the right time with the right dissemination approach, one that is neither too detailed nor too abstract for the user's current level of interest and understanding.

Our interview analysis also helped to uncover the factors that make research university professors more or less receptive to various dissemination approaches and various reforms. Approaches that allowed some form of personal contact between the disseminator/reformer and the potential user of the reform were preferred by the vast majority of professors. Approaches that allowed professors to get the most useful information in the least amount of time were also preferred. Of course, the definition of "useful" varied depending on the professors and the stage of the adoption process they were in, as seen by the variety of responses we got to the dissemination materials we sent. As for professors' receptiveness to the reforms themselves, we found that research professors were more likely to be open-minded and comfortable about trying a reform if it has been endorsed by an esteemed colleague or research institution. Professors at research universities not only need to know that a reform "works," but that it works for someone *like them*—someone who has large classes, limited time, and pressure from colleagues to focus on research. When an esteemed colleague at a research institution endorses a reform, it not only suggests that the reform can work in such a setting, but it helps to win departmental support for the reform by boosting its credibility and noteworthiness.

Finally, it should be recognized that even if a dissemination approach is very effective at informing people about a reform, and even if the disseminator can provide substantial evidence that the reform "works," many professors will still be reluctant to try the reform themselves. Sometimes this is due to personal barriers like discomfort with change, deeply-ingrained preconceptions about "the right way" to learn, doubts about whether the reform is even necessary, or—that prickliest of fences—intellectual territoriality (i.e., "No one's going to tell me what to do in *my* classroom.") Other times, such reluctance is due to institutional barriers like the expectation that professors will cover a fixed body of material in a relatively short amount of time, the comparatively low emphasis placed on teaching at research universities, a lack of departmental or collegial support for taking the time to pursue reforms, and the difficulties in making certain reforms work with large classes in large classrooms. Future research should focus on how successful reforms have addressed and overcome professors' personal barriers to reform, and what should be done at the administrative level to encourage the lowering or lessening of institutional barriers to reform.

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