Diffusing STEM Pedagogies: The Role of Opinion Leaders

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Abstract

Faculty may learn of new pedagogies through mass communication channels such as Web sites, journals, and workshops. Faculty are likely to be persuaded to try these new pedagogies, however, by interpersonal communication with an opinion leader. Using literature and exploratory data we contrast awareness and persuasion and suggest that opinion leaders in departments can play a critical role in the diffusion of STEM pedagogies. We conclude with actions administrators can take on their own campuses to promote adoption of STEM pedagogies.

Diffusing STEM Pedagogies

Broadly speaking, the large-scale dissemination of STEM pedagogies can be framed as a problem of diffusion. Diffusion is the process by which innovations are communicated through certain communication channels among the members of a social system (Rogers 2003). Applied to STEM pedagogies, the pedagogy is the innovation—an idea, practice or object perceived to be new by a faculty member or academic department. The communication channels are the means by which messages about the innovation get from one individual to another, that is, how potential users (adopters) of the innovation—perhaps a faculty or entire department—learn about the innovation. Mass media communication channels, such as journal articles, white papers, Web sites, and book flyers, are effective in creating knowledge of the innovation. Interpersonal communication channels, such as conversations with respected colleagues or disciplinary leaders, are typically more effective in forming and changing attitudes toward the innovation, and thus influencing the decision to adopt or reject the pedagogy. Finally, a social system is a set of interrelated units that are engaged in joint problem-solving to accomplish a goal—such as an academic department or a faculty member and teaching assistants who instruct a basic course.

How does diffusion work in practice? Consider this scenario:

> *John has been an assistant professor in engineering at a California State University campus for two years. He wants to improve his teaching for many reasons: to increase student learning gains, to make teaching a more intrinsically rewarding experience, and to show his willingness to work on his teaching as his three-year review is one year away. So John attends a teaching workshop on problem-based learning offered by an engineering professional association before the start of the annual conference. The workshop is interesting to John. He takes ideas from the workshops and tries to*

incorporate several of them into his class, but beyond the initial effort, the notebooks from the workshop sit on the shelf and he never goes to the Web-based support site. Overall, he does little to change his approach to teaching, the structure of the course or the content of the course. Later in the term, Judy, a senior colleague, comes to John's office. Though he has never seen Judy teach, John admires her teaching ability based on students' and faculty casual comments about what a good teacher Judy is, the fact that Judy won a department teaching award and several of her advisees have gone on to top notch graduate programs. John describes the workshop to Judy. She then tells John that she has been using problem-based learning in several of her courses. John and Judy discuss problem-based learning and Judy encourages him to continue experimenting with problem-based learning, suggesting tips and telling him that it takes time to feel really comfortable with it. Later that day, John pulls the notebooks off the shelves and begins to map out how he will integrate problem-based learning into his freshman class.

This scenario demonstrates a typical diffusion decision-process for an individual: knowledge is gained through the largely one-way communication of information (a workshop, workbooks, Web site); persuasion occurs through the two-way communication of social influence in the form of Judy, a local opinion leader; and a positive adoption decision is made to try a new practice. And note what did not happen: information alone was insufficient to move John toward a positive adoption decision. Evidence of the effectiveness of the pedagogy gained from the workshop was insufficient to move John to fully adopt or sustain the new behavior. Talking was key! And it was not just anyone who was able to move John to action. It was a person John already believed to be expert and trustworthy. Judy reduced John's perceived risk or uncertainty about the innovation. Social influence in the form of an opinion leader was key to the adoption decision.

Studies of university faculty engagement with new pedagogies have focused on the organizational reasons why faculty change their teaching methods (Bess 1997), on the psychological basis for use of alternative teaching methods (Colbeck, Cabrera, and Marine 2002), and on demographic characteristics that may affect teaching behaviors (Finkelstein, Seal, and Schuster 1998; Fairweather 1997). Such studies are important, but they tend to overlook the communicative and interpersonal aspects of how faculty become aware of and are persuaded to experiment with new practices.

An individual's decision to adopt a new pedagogy is not an instantaneous act. Rogers (2003) describes an innovation-decision process where stages or actions related to the eventual implementation of an innovation occur over time. This innovation-decision process begins with an individual becoming exposed to an innovation's existence and gaining some understating of how it functions. This is the knowledge stage. As potential adopters become familiar with the characteristics of the innovation such as its complexity and relative advantage(s), as well as how it fits with the organization, they form a favorable or unfavorable attitude toward the innovation. This is the persuasion stage of the innovation-decision process. Where the focus in the knowledge stage is

primarily cognitive (or knowing), the main type of thinking at the persuasion stage is affective or feeling. Rogers (2003) states that until the individual knows about a new idea, her or she cannot begin to form an attitude toward it. Once an individual becomes aware of an innovation and forms a favorable or unfavorable attitude, they are then positioned to make a decision to adopt or reject the innovation or engage in a small-scale trial where they "try-on" the innovation.

Faculty become aware of and are influenced to adopt, or not, an innovation through communication. Communication originates with a source and moves through channels. The source—the originator of the message—can be an individual or an organization. The channel, the means by which the messages gets from the source to the receiver, can be either mass media or interpersonal in nature and may originate from local or distant sources. Typically, mass media channels, such as Web sites, flyers, newsletters and so on, are relatively more important at the knowledge stage than at the persuasion stage. At the persuasion stage—when potential adopters are forming or changing attitudes—it is interpersonal channels that involve a face-to-face exchange that are of greater importance.

Much of the dissemination effort associated with STEM pedagogies are aimed at communicating knowledge or awareness of the innovations. Perusing NSF-funded STEM pedagogy projects with dissemination components surfaces the use of Web sites, workshops, guidelines, workbooks and other communication products or processes that generate awareness. According to diffusion theory, awareness is necessary but likely insufficient to generate positive adoption of pedagogies by STEM faculty. We need persuasive communication in the form of face-to-face or interpersonal communication from a respected other. We believe that opinion leaders are uniquely qualified to persuade faculty to try-on an innovation. In fact, one or two opinion leaders in a department could persuade or influence an entire department to adopt a new pedagogy. Who and what are opinion leaders? And why are they so important in the diffusion process?

Opinion Leaders: Influencing Adoption through Interpersonal Communication

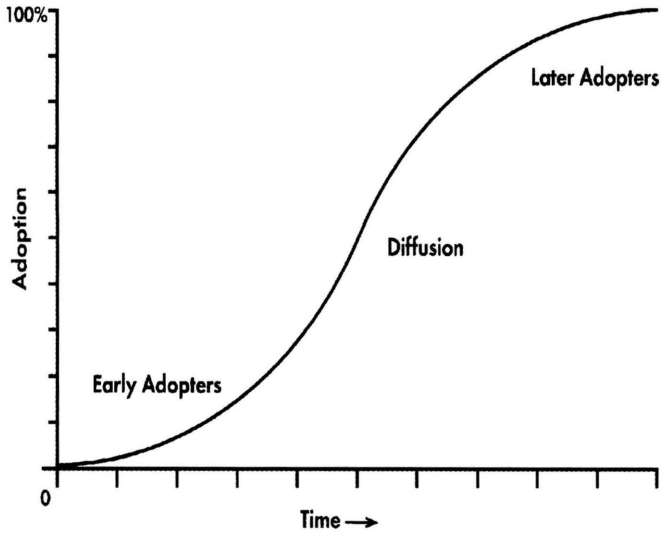
Interpersonal communication typically consist of few participants, perhaps only two, with opportunity for immediate feedback. As such, the ability to reduce perceived risk and uncertainty often associated with innovations is more likely through interpersonal communication than it is through mass communication. And those having the greatest interpersonal influence are opinion leaders. Opinion leaders are individuals who are able to informally influence other individuals' attitudes or overt behaviors regarding an innovation. Opinion leaders provide information and advice about innovations to numerous individuals in any social system. This informal influence is not a function of formal position or status in the system. Rather, opinion leadership is earned and maintained by the individual's technical competence, social accessibility, and conformity to the system's norms (Rogers 2003).

Rogers (2003) describes opinion leaders as differing from their peers in several important ways. For one, opinion leaders have greater exposure to mass media than their followers. It is from this access to ideas that opinion leaders gain perceived credibility. Another is that opinion leaders are accessible. What makes them accessible is a relatively high degree of social participation in a system and extensive interpersonal networks. We find opinion leaders engaging in face-to-face communication with many people. Lastly, in systems with traditional norms, such as higher education institutions, opinion leaders are not usually innovators—those who develop the new ideas. Opinion leaders are likely to conform to system norms and take their time to arrive at an adoption decision. In universities, we would expect opinion leaders to demonstrate prudent judgment in decisions about adopting new ideas.

The role of opinion leader in the diffusion of innovations has been well substantiated. Research has shown, for example, that opinion leadership tends to be stable over time (O'Brien, Raedeke, and Hassinger 1998) and function consistently across similar social systems such as hospitals (Soumerai et al. 1998), schools (Valente et al. 2003) and towns (Sen 1969). Coleman, Katz, and Menzel (1957) were among the first researchers to study opinion leadership, documenting the role of opinion leaders diffusing information about new drugs among physicians. Carlson (1965) noted the importance of opinion leaders in educational innovations with his study of the diffusion of modern math among superintendents in Pennsylvania. More recently, Kelly and his colleagues (Kelly et al. 1991, 1997) have demonstrated the effectiveness of diffusing HIV prevention information via local opinion leaders. Rogers (2003), however, provides what may be the strongest evidence in support of the efficacy of opinion leaders as a purposeful diffusion strategy. He notes results supporting the efficacy of opinion leaders in eight separate experiments. What is particularly noteworthy is the fact that all experiments were randomized control trials representing highly rigorous tests of experimental effects.

Diffusing STEM Innovations via Opinions Leaders: Accelerating Adoption

The important role opinion leaders play in the diffusion of innovations can be more fully appreciated by considering the typical way in which new ideas spread. Adopters can be categorized chronologically according to the time of adoption. Innovators, for example, characterize the first 2.5% of adopters followed by early adopters (next 13.5%), the early majority (next 34%), the late majority (next 34%) and finally laggards who comprise the remaining 16% of adopters. As is the case with many phenomena, the rate of innovation adoption is often normally distributed so that when adoption is plotted cumulatively over time an S-shaped curve results. As can be seen in the figure below, adoption starts out slowly as innovators begin to take a chance on the new idea. The rate of diffusion then picks up momentum as early adopters decide to try out the innovation. It is at about this time (between 10% and 20% of adoption) that diffusion "takes off" at a very rapid pace as depicted by the steep incline of the curve. In fact, once adoption reaches this point, continual spread is a near certainty.



Why does the diffusion curve "take off" with early adopters, rather than earlier with innovators? As a group, innovators are quite dissimilar to others insofar as (1) they are more cosmopolitan with connections outside the local social system, (2) they have greater resources with which to take chances on new ideas, (3) they are more comfortable dealing with uncertainty, and (4) they have a greater capacity to understand and apply complex knowledge (Rogers 2003). As a result, these individuals are perceived to be significantly different by others in the social system and thus do not serve as a source of great influence to many others. Early adopters, on the other hand, are characterized by a disproportionate number of opinion leaders who are highly integrated among their peers, trusted and well-respected. Because they are perceived to be quite similar to many others in the social system, they are sought out for their advice about what new ideas to adopt. Opinion leaders, therefore, play a vital role in the diffusion process by activating social networks in a way that others cannot. And the key lies in their extraordinary position within the social system to influence many others thereby creating exponential increases in adoption.

Key, then, to effectively disseminating STEM pedagogies across departments and disciplines are opinion leaders. What follows are findings from an exploratory study of communication channels and opinion leaders with respect to accelerating the diffusion of STEM pedagogies within three departments at each of six campuses.

STEM Faculty Sources of Knowledge and Influence: An Exploratory Study

With funding from the National Science Foundation, the authors, along with James Dearing, initiated a formative study to identify how we might best inform faculty and persuade them to adopt, or at least consider adopting, STEM pedagogies. Our research focused on faculty in distinct departments of chemistry, mathematics, and physics with at least ten full-time faculty members and where minority student populations were at or above the national average. Associate Colleges and Baccalaureate Colleges were eliminated from the study because many did not have distinct departments of physics and many chemistry and math departments had fewer than ten full-time faculty. Carnegie classified Doctorate-granting Institutions and Master's College and Universities were thus considered.

We purposively sampled from this list to ensure geographic representation and interviewed faculty and chairs in chemistry, mathematics, and physics at these six universities: Old Dominion University, University of Central Oklahoma, Southern Illinois University-Edwardsville, University of Maryland-Baltimore County, California State University-Northridge, and San Francisco State University. The chairperson and randomly selected faculty from each department were contacted. In all, ninety-four faculty members and chairs were contacted and sixty completed our telephone interview (sixteen chairs and forty-four faculty members) that lasted approximately twenty-five minutes.

Respondents were evenly distributed across physic, chemistry and math departments. Most respondents were experienced teachers, with 40 percent having taught at least part-time for ten to twenty years and another 40 percent teaching twenty-one or more years. Only five respondents (8 percent) had taught fewer than five years. Most respondents taught courses at the freshman or sophomore level. In the past five years, 60 percent of respondents had taught six or more freshman or sophomore classes and another 30 percent had taught one to five such courses. Only 10 percent of respondents reported not teaching at this level in the past five years. Two-thirds (67 percent) of respondents also reported participating in a teaching workshop or other type of teaching enhancement program. Taken together, these characteristics suggest that our respondents were familiar with teaching and perhaps committed to teaching well. Study results follow.

Mass and Specialty Media Communication: Creating STEM Innovation Awareness

Faculty members may learn about STEM pedagogies from association Web sites and related non-referred publications; through announcements for national, association and campus-sponsored workshops; at professional conferences; and through journals in their fields. We define these types of communication channels as mass or specialty media because they are primarily one-way information exchanges targeted to a fairly broad audience. These communication channels are important in the diffusion process because they can trigger knowledge and awareness of new pedagogies.

Disciplinary associations have the means to disseminate knowledge about pedagogical innovations, but do faculty pay attention to these channels? Nearly all faculty in this study (98 percent) indicated that they pay attention to at least one professional association. Faculty also pay attention to academic journals or disciplinary publications, with 90 percent monitoring at least one journal, including 52 percent who monitor three or more journals. Only 10 percent of those faculty interviewed do not follow at least one academic journal. Disciplinary conferences are also important – 87 percent of interviewees pay attention to at least one such conference. Faculty appear predisposed to pay attention to messages communicated through association related channels. But do these mass media sources influence or persuade faculty to change their practices?

Consistent with diffusion literature, these mass communication channels appear more effective at informing than persuading faculty. While 90 percent of the respondents monitor at least one academic journal, only a little more than one-third (37 percent) of respondents said that academic journals influence their teaching. Similarly, 87 percent of respondents pay attention to at least one conference, but less than half that number of respondents (39 percent) indicate that academic conferences influence their teaching. More influential are association-sponsored teaching workshops or seminars with 60 percent of the respondents indicating these influence their teaching.

Faculty may also hear about new pedagogies from teaching centers on their campuses. These centers may be able to develop messages that fit the organizational context and strategically target messages to selected faculty members. As such, teaching centers could play an important role in informing and possibly persuading faculty to change their teaching practices. Over half of the faculty (56 percent) said they would visit a Web site to learn more about effective pedagogies if the message came from a teaching development center on campus and nearly half (47 percent) of the respondents indicated campus-based workshops influenced their teaching. Workshops sponsored by associations and teaching centers have greater influence than journals or conferences on changing teaching behavior.

Faculty in this study pay attention to messages coming from professional or academic associations. Associations are well positioned to provide information—to create awareness about effective pedagogies through their Web sites, publications and conferences. But more than awareness is required for adoption to occur—persuasion is typically required for faculty to try out new ideas. Workshops are more influential. Workshops tend to be interactive, requiring participants to share their ideas and experiences. As such, workshops are a blend of one-way and face-to-face communication. This may account for the fact that workshops are more influential than journals or conferences that tend to be one-way exchanges of information.

Workshops, then, may be a good way to persuade faculty to make behavior changes. But workshops do not always lead to behavior change, even though participants are often predisposed to making such changes (Connolly and Millar, 2006, this issue). Diffusion via workshops is also time consuming, costly and slow. To effectively and efficiently accelerate the diffusion of teaching practices to all or most faculty we can build on existing communication systems by targeting opinion leaders.

Interpersonal Communication: Moving Toward STEM Innovation Adoption

Once faculty are aware of pedagogical innovations they need to be persuaded to try them. Opinion leaders—those deemed as influential, credible and accessible—can provide this persuasion. Do opinion leaders exist in STEM departments? Individuals who are not only knowledgeable and accessible, but who are also able to persuade faculty to experiment with or adopt new pedagogies? This was the central question in our study.

Exploratory data indicates that some individuals who faculty have access to are opinion leaders, while others are not. For example, most faculty have access to university administrators, but, and not surprisingly, university administrators have minimal impact on faculty teaching. Only 13 percent of respondents indicated that university administrators influence their teaching. University administrators are unlikely to be effective opinion leaders with respect to STEM pedagogies.

We found opinion leaders residing within departments and within the discipline. Respondents easily identified faculty in their departments whose opinions they highly value. Faculty and chairs gave 128 responses to the question of who within their department they find influential. When asked why they thought highly of the person, respondents most frequently described the faculty member as being an effective or conscientious teacher. The second most frequent description focused on the overall expertise of the faculty member in terms of his or her intellect and/or knowledge. Clearly, those identified are viewed as being technically competent and they are likely socially accessible as they are within the same academic department. We believe that respondents were identifying pedagogical opinion leaders.

Nearly all respondents (93 percent) identified a departmental opinion leader and over one-third (40 percent) of the respondents identified three opinion leaders in the department—the maximum numbered allowed on our survey instrument. In twelve of the eighteen departments, the same individual faculty member was identified by at least two respondents as being an opinion leader. This suggests the possibility of convergence—of one or two faculty members influencing most or many faculty in the same department.

Faculty members frequently identified chairs as departmental opinion leaders. In eleven of the eighteen departments, chairs were identified by at least one faculty member as an opinion leader, and in seven of these departments at least two respondents identified the departmental chair as an opinion leader. In addition, chairs were somewhat likely to identify the same faculty opinion leaders as did regular faculty members. Although university administrators may not be opinion leaders, department chairs or directors may be.

It seems likely that opinion leaders can be found in academic departments. Chairs may be opinion leaders and chairs may also be reliable sources for identifying opinion leaders in departments. But are opinion leaders likely to persuade faculty to try out new pedagogies? We asked faculty if they would seriously consider adopting or changing the content of a course if encouraged by the department opinion leader they identified. Eighty-two percent said they would be likely or very likely to do so. Regarding changes in how they teach (versus content), 75 percent of faculty would consider making changes in how they teach based on the recommendation of the opinion leader.

Given the importance of the invisible college or disciplinary identity, it is reasonable to assume that faculty may also be successfully persuaded to consider pedagogical changes by disciplinary opinion leaders. Such near-peers may not be socially

accessible, but their expert status may yet be influential. We asked respondents if there was one or perhaps several individuals within their disciplines or area of study whose opinion they highly valued. Faculty and chairs identified fewer disciplinary opinion leaders (eighty-four responses) than departmental opinion leaders (128 responses). Almost a quarter of respondents (23 percent) did not identify an opinion leader outside the department. Of the eighty-three people associated with the discipline but outside the department, only one was mentioned twice. The specialization within a discipline may explain the lack of convergence in the identification of disciplinary opinion leaders—different subfields pay attention to different opinion leaders. It is also possible that disciplinary opinion leaders are less suited to influencing teaching behaviors. Descriptions of disciplinary opinion leaders tended to focus more on research expertise than teaching competence. Since disciplinary near-peers may not be accessible for interpersonal communication, we asked faculty if they would visit a Web site if encouraged to do so by a disciplinary opinion leader. Nearly all faculty, 91 percent, said they would. This indicates that disciplinary opinion leaders outside the respondent's department may play an important role in encouraging faculty to learn more about an innovation—to gain knowledge and possibly reduce uncertainty.

In summary, our exploratory research indicates that communication channels, especially disciplinary channels, are already being used by faculty, although it is not clear if faculty are actively seeking information or more passive recipients. Influence via opinion leaders is possible, perhaps even likely, in departments; responses indicate a convergence in several units in the identification of opinion leaders. Further, department chairs may be opinion leaders. Opinion leaders identified by respondents were likely to be quite persuasive; faculty would be willing to reconsider what and how they teach if an opinion leader suggested they do so. However, for opinion leaders to influence others to use new pedagogical practices, they themselves must "buy" into the innovation and feel compelled to tell others. Ultimately, we need dissemination strategies targeted to these opinion leaders if we want to accelerate the diffusion process.

Knowledge and Influence: Next Steps in Research and on Your Campus

Preliminary research raises many additional questions associated with the diffusion of STEM pedagogies. We now turn our attention to what we believe are a few of the most interesting and potentially beneficial research questions that might be addressed in future studies. We conclude with a discussion focused on immediate local responses that can be undertaken while awaiting research results.

Setting the Agenda for Diffusion Research of STEM Innovations

1. Can departmental chairpersons serve as opinion leaders for STEM innovations?

Preliminary research suggests departmental chairpersons are often viewed as opinion leaders. If chairpersons are, in fact, regularly viewed as opinion leaders within their

departments, then the need to identify opinion leaders via sociometric survey or other time consuming method would be alleviated. Such a finding would enable STEM innovation sponsors to easily identify and contact an important source of departmental influence.

If departmental chairpersons cannot be established as opinion leaders, preliminary research suggests they may be a reliable source for identifying who in the department is perceived as an opinion leader. Future research therefore might look at the extent to which chairpersons can reliably identify departmental opinion leaders since this finding, too, would greatly simplify the diffusion process.

2. What role can a disciplinary opinion leader play in the diffusion of STEM innovations?

From a diffusion perspective, the potential efficiencies associated with a disciplinary opinion leader are enormous. As such, it is important to know whether or not it is possible to identify disciplinary near-peers known and respected for their pedagogical accomplishments in STEM-related fields. Although preliminary research was somewhat discouraging, this question is worthy of further investigation given the potential benefits and the fact that of those identifying disciplinary leaders, 91 percent indicated they would visit a Web site if encouraged to do so by a disciplinary opinion leader.

3. What, specifically, should opinion leaders do to influence others to adopt innovative STEM practices?

Regardless of how opinion leaders are identified and whether they are located within or outside a department, specific method(s) of influence must be assessed to determine those that are most effective within the context of diffusing STEM innovations. Relatively more active influence strategies might include an informal brown bag seminar, mentoring, coaching or other personalized discussions. Less active strategies might include a letter or e-mail correspondence directing recipients to a Web site. Efficacy aside, this question is complicated by the fact that the process of influence via opinion leaders is an informal one that may be compromised if opinion leaders are asked to play a more formal or authoritative role in the diffusion process. And of course, the more an opinion leader is asked to do, the less likely he or she will be to agree.

4. What unique aspects exist across disciplines that may differentially affect the diffusion of STEM pedagogies via opinion leaders?

While specific strategies associated with STEM innovations may be broadly implemented within and across disciplines, the effectiveness of opinion leadership as a diffusion technique may differ widely. Disciplinary opinion leaders, for example, may be easily identifiable in engineering but not mathematics. And differences may exist within disciplines as well where, for example, disciplinary opinion leaders are

common in biochemistry but not organic chemistry. Therefore, if a one-size-fits-all diffusion strategy cannot be assumed, then specific nuances need to be uncovered.

Immediate Local Response

Answers to the above questions will provide valuable information about how best to diffuse STEM pedagogies using opinion leaders. But what actions can be taken now, before these questions have been addressed? We provide six ideas for moving forward on metropolitan campuses.

First, create awareness. As noted earlier, the diffusion process typically begins with awareness. It is quite possible that faculty, including opinion leaders, are neither aware of STEM pedagogies or the validation studies funded by NSF. So the first step, and something that can be facilitated with relative ease, is to make STEM innovations known to faculty. This can be done in a variety of ways. Many campuses, for example, have formally established teaching centers designed specifically to improve faculty pedagogy. Workshops, seminars and brown bag lunches, to name a few, are likely all common interactive approaches that may be used to introduce STEM practices. Mediated approaches such as a Web site or list serve may also be viable means for creating awareness about, and sustaining interest in, STEM innovations.

Awareness among interested faculty may lead to eventual adoption and trial by one or several interested faculty members. Of course, there is no guarantee that any one of these individuals will be an opinion leader. If one turns out to be, so much the better. If not, at least some implementation has occurred that may lead, even serendipitously, to further trial by others.

Second, partner with a teaching center on campus if you have one. Teaching centers are frequently staffed by faculty and professionals familiar with general pedagogical approaches to teaching and learning in higher education. These staff may not be familiar with the impressive work specific to STEM education. Increasing their expertise in this topical area could be a first step in diffusing these STEM pedagogies on your campus. Once familiar with a range of choices, staff at teaching centers could provide workshops specific to STEM departments or encourage faculty to attend one of the many workshops offered by innovators and/or sponsored by NSF. We need to make use of resources already at hand!

Third, start small but strategically. A significant benefit of a diffusion approach lies in its efficiency, where a single faculty member is able to influence the decision-making of numerous others. With this in mind, consider starting slowly by identifying even one faculty member in a single department who you have good reason to believe may be especially influential. Such a determination may be based on personal or anecdotal knowledge of a faculty member who has had consistent influence within his or her department over time. Such an individual may be an ideal choice early on, especially if previous influence was not tied to a position such as a departmental chairperson or director of graduate or undergraduate studies. A faculty member recognized for

extraordinary teaching may also be a good choice. Already respected for his or her pedagogical achievements, others will be open to new teaching strategies suggested by this person. It is also quite likely that this individual will be open to new practices that lead to pedagogical improvement. Once identified, and interest in implementing STEM practices substantiated, then work closely with this individual to ensure he or she has a thorough working knowledge of the innovation.

Fourth, consider incentives. Regardless of how interested identified faculty are, consider providing incentives for trying out STEM innovations. A significant barrier to implementing new pedagogical practices is the additional time needed to do so. And in an environment characterized by ever increasing demands on faculty time, even those most likely to make change may be reticent to do so. So an incentive that frees up some time will likely increase agreement and participation. A one-time single course release, if possible, may be just the right incentive. A reduced advising load or limited committee assignments might also be attractive to faculty members. A summer teaching appointment to experiment with the new pedagogy is another option. In the end, recognizing the value of faculty time through some incentive will pay large dividends both in terms of implementation effort and goodwill.

Fifth, when faculty on your campus attend workshops or seminars on teaching and new pedagogies ask them to share their knowledge and experiences with others. These faculty could be encouraged to speak at a brown bag lunch, present a seminar, or join a learning community. This helps to generate awareness among faculty and possibly act as a form of persuasion. It certainly reinforces the learning experience for the faculty.

Finally, assess results. While faculty members implementing STEM innovations may note positive change both in the classroom and in test results, others will need more formal evidence. Ideally, learning outcomes can be measured and compared against prior results. If this is not possible, faculty might be willing to keep a weekly journal identifying changes or perhaps complete a few qualitative questions at one or a few points during the term. Additionally, of course, students can provide their perceptions of the innovative practices through a questionnaire or perhaps even via a focus group if several class members would be willing to do so. Assessment data will prove beneficial as efforts are made to move forward with STEM practices beyond a single opinion leader or a few faculty innovators.

Conclusion

If we want large-scale dissemination of STEM pedagogies, we need to pay attention to how faculty learn about pedagogies and who or what reduces the uncertainty and risk associated with trying-on a new practice. We argue that effective use of opinion leaders will accelerate and increase adoption on campuses. Our preliminary research indicates that communication channels are in-place to inform faculty of pedagogical innovations, especially through disciplinary channels such as journals and conferences. Data also offers some support for the existence of opinion leaders being present within academic

departments—individuals who can use interpersonal communication to reduce potential adopters' uncertainty and risk associated with an innovation.

While we cannot offer definite suggestions steeped in research for diffusing pedagogies on campuses, we do conclude with a set of recommendations consonant with ideas expressed in the diffusion of innovation literature and with our data from our exploratory study. Finally, although we have not discussed the role of the adopter in the diffusion process, we recognize that adopters (faculty) can be full partners in the diffusion process, especially as they try out and adapt new pedagogies. What we want to do is to accelerate getting to the point where faculty are persuaded to experiment with the innovations.

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