

Successes and Constraints in the Enactment of a Reform

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Abstract. Despite research documenting the potentially positive impacts of research-based instructional reforms in physics, few high school physics teachers in the US enact them. One of the more successfully disseminated reforms is Modeling Instruction. To discern aspects of this reform that afforded or constrained its dissemination, we analyzed the interviews of five people involved in the development of Modeling Instruction. Our findings are framed within theoretical perspectives from the communities of practice, diffusion of innovations, and leadership.

Keywords: Modeling Instruction, dissemination, communities of practice, diffusion of innovations, leadership

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INTRODUCTION

Considerable amounts of time, effort and money have gone into the development and dissemination of many research-based instructional reforms; however, these reforms are often weakly integrated into classroom practice [1]. Traditionally, dissemination efforts by researchers of STEM teaching practices have been conceived as top-down approaches, starting with research and trickling down to practice. However, this approach has been criticized for not taking into account the perspectives of its intended recipients [2]. Educational researchers have come to realize that those perspectives are vital to successfully enact reform. To improve the impact of these reforms, it is essential to address the perspectives of the recipients with respect to the critical, yet often neglected, issues of dissemination.

One way to approach this concern is to look at the dissemination efforts of reforms that have achieved some measure of success. Within physics education, one approach that has impacted large numbers of physics classrooms is the Modeling Instruction project [3]. Which aspects of this project have made this reform relatively more widespread and sustainable than other reforms? What can be learned from the dissemination of this project that may help improve the impact of other reforms? In this paper, we will (1) describe Modeling Instruction and some of its dissemination methods, (2) report on an analysis of the interviews with five members involved with its development, (3) embed the dissemination of the project in a larger theoretical framework, and (4) offer recommendations based on this analysis for those interested in promoting research-based reforms.

Description and History of the Project

In addition to producing larger gains in student conceptual understanding of physics than traditional methods of instruction, Modeling Instruction has met or exceeded current content, assessment, inquiry, teaching, and professional development standards [4]. It is also grounded in research-based pedagogical techniques that can help instructors develop their students' abilities to make sense of observed physical phenomena, understand scientific claims, articulate their own coherent opinions, defend those opinions with rational arguments, and evaluate evidence to support their justifications. These techniques revolve around a set of scientific models representing physical phenomena with the intent to make instruction in physics reflect activities of practicing physicists. To do this, instruction is organized such that students move through various phases of model development, evaluation and application.

The enactment of this reform involves two stages: model development and model deployment [5]. In the first stage, students develop a mathematical model that reflects physical phenomenon. In the second stage, students apply their constructed model in novel situations to gain familiarity and practice using their constructed models, which helps to promote student ownership of them. However, the enactment of these stages is highly dependent on the level of discourse management by the teacher. To develop this expertise, teachers attend a Modeling workshop. The first workshop was led by Malcolm Wells in the summer of 1991 and was comprised of high school teachers from Arizona. The workshop focused on mechanics, using

technology to support teaching and help manage classroom discourse. These participants also made a commitment to participate for three successive years.

The project expanded to include an additional workshop in Chicago the following summer of 1992. As the number of workshops continued to grow, so did their scope and emphasis. Because the leadership team understood that growing the project would require additional leaders, they began to vet participants to lead their own workshops. Through a national dissemination grant, workshop leaders were trained and encouraged to work with faculty at local universities to submit proposals to hold local Modeling workshops. These participants developed additional content materials (e.g. electricity and magnetism, etc.), in addition to refining materials for the mechanics curriculum. Since its inception, over 3,000 educators have participated in a Modeling workshop. In summer 2011, workshops were held in 25 states.

Theoretical Perspectives

The successfulness of Modeling Instruction will be viewed from the perspective of three theoretical frameworks: communities of practice [6], diffusion of innovations [7], and leadership [8]. These frameworks were chosen based on prior research [9] and fit with our data; each is briefly described in the following.

In the seminal work on legitimate peripheral participation [6], the concept of community of practice (CoP) was first coined to informally label the ideas to explain learning as apprenticeships of social practices. CoP's are characterized by three elements: domain, community, and practice [10]. First, participants in a CoP share a domain of interest, which distinguishes members from non-members. Second, participants build relationships within their community that enable them to learn and interact with each other. Third, participants are practitioners who develop a shared practice, or repertoire of resources sustained over time. These elements develop in parallel to constitute a CoP.

According to the diffusion of innovations [8], innovations are ideas perceived as new by individuals or other adopting units. Individuals adopt innovations through five stages (knowledge, persuasion, decision, implementation, confirmation). The rates of adoption are attributed to features of the innovations (relative advantage, compatibility, complexity, trialability, observability). These stages and features are related to the interaction between the innovation and adopter.

In the leadership framework [9], leaders are traditionally expected to reduce complexities in their organizations by trying to control for some desirable future; but the unpredictable nature of organizations makes this challenging. The ways in which leaders

interact within their organizational contexts to enable change depends on the quality and type of interactions between the leaders and their organizations. Thus, leaders who are successful enable interactions for a desirable future instead of directing them.

METHODOLOGY

In spring 2007, four participants were purposefully selected to be interviewed based on their extensive and initial involvement with the development of the Modeling Instruction project; no one else had worked with this reform as extensively. Based on participant suggestions, a fifth person was included in our list of interviewees. Interviews were conducted over the telephone and audiotaped. Interview questions mostly pertained to the goals, philosophies, successes/failures, and evolution of the Modeling workshops, and were open-ended and semi-structured. Afterwards, the audiotaped interviews were transcribed for analysis.

Our analyses of the transcripts were based on grounded theory [11]. A key feature in this approach is the systematic collection and analysis of data through a constant comparative method. Two authors (Dancy and Lee) first analyzed each interview individually by creating codes based on the purpose of the question (e.g. *dissemination effort*). These codes were then compared to each other, with discrepancies resolved through discussion. Afterwards, codes were organized into themes (e.g. themes emerging from the code *dissemination effort* included *building of community* and *empowerment of participants*). All four authors discussed and made minor modifications to the themes. Through multiple iterations of this process, patterns that emerged from our themes were then established and linked to our theoretical perspectives to reflect our efforts in modeling the dissemination of the reform.

It is important we note our particular familiarities with Modeling Instruction prior to the analysis of the data. Two authors (Brewer and Lee) were familiar with Modeling Instruction, having used it for instruction in their classrooms. The two other authors (Dancy and Henderson) had heard about Modeling Instruction, but were not as familiar with it. Collaborative discussions throughout the data analysis process helped to reduce and balance potential biases in the findings.

FINDINGS

With respect to factors that contributed to the dissemination of Modeling Instruction, the eight final themes that emerged from our analysis are listed and described below, followed by sample excerpts. Some of the excerpts can be associated with multiple themes.

Themes from Interviews

1. *Building of community* – integration of participants to Modeling Instruction through the creation of personal connections.

... it [modeling] is the building of the community and the treatment of the dignity of the members of the community that is so important... (P2, 216-218)

...the camaraderie that develops from the teachers...[is] a large component of the success. (P3, 212-213)
2. *Dissemination by participants* – propagation of Modeling Instruction by participants.

...it [modeling] creates people who are more sure of themselves...and those are the kind of people who are going to extend themselves to mentoring others, giving workshops, giving conference presentations, taking on student teachers... (P4, 437-440)
3. *Distribution of leadership* – distribution of project ownership among participants.

...we were trying to take people we thought were the best teachers that we thought could lead workshops elsewhere or that could serve as role models for other people to follow. (P1, 69-70)
4. *Empowerment of participants* – empowerment of participants to be activists for their benefit.

...teachers became sufficiently grounded in what was going on so that...they could continue and they wouldn't be dependent on a curriculum that was developed at modeling central. (P1, 181-183)
5. *Organization of curricula* – encouragement of participants to create and/or modify the curricula.

...we make it [Modeling curricula] available in Word so it is editable and teachers could choose to take it and change it to suit their styles rather than change their styles to suit the materials. (P1, 195-197)
6. *Supports for enactment* – provision of resources to implement Modeling Instruction.

...Jane not only builds up connections with the teachers, she's always there to answer every e-mail...and has created a package that helps people make proposals for local funding... (P2, 254-259)
7. *Supports for sustained implementation* – resources to continually support participant implementation of Modeling Instruction after the workshop.

...it's [listserv] hugely important just in terms of giving, well it's important in different ways at different points in your development as a modeler. Initially it's a life preserver. (P4, 330-351)
8. *Testimonials of effectiveness* – affirmations of Modeling Instruction “working” in the classroom.

...the crossover teachers are just as good as the one who are physics majors and they can teach physics just as well and within three years, we can get them doing as well on FCI scores by and large as those physics teachers who have training in physics. (P2, 534-537)

...I've got a whole lot of...unsolicited e-mails from teachers during the school year...I'm just overwhelmed by their enthusiasm. (P3, 131-134)

...when I saw substantial increases in their ability to articulate things, their scores went up on the tests...[that's when] I really became committed to it [modeling]... (P5, 125-129)

The number of interviewees, whose responses we corresponded to our themes, is presented in Table 1.

TABLE 1. Interviewee Responses (N=5)

themes	#
<i>Dissemination by participants</i>	5
<i>Distribution of leadership</i>	5
<i>Testimonials of effectiveness</i>	5
<i>Building of community</i>	4
<i>Empowerment of participants</i>	4
<i>Supports for enactment</i>	4
<i>Organization of curricula</i>	2
<i>Supports for sustained implementation</i>	2

Most themes were identified by the majority of the interviewees; however, *organization of curricula* and *supports for sustained implementation* were only noted by two of them. Although these themes are listed distinctly, they build on and support each other. To formulate a relationship between these themes and explicate their contributions to the dissemination of Modeling Instruction as noted by the interviewees, we present our interpretation of the themes from the perspective of our three theoretical frameworks.

Implications for Dissemination Efforts

Modeling Instruction, like many other research-based reforms, is an educational innovation. Teachers who adopt Modeling Instruction (modelers) are more likely to do so if its features are compatible with their perceptions of teaching [7]. From our initial analysis of the data, it was apparent that one theme played a significant role in the relative successfulness in the dissemination of Modeling Instruction as perceived by the interviewees: *empowerment of participants*. This theme was supported by the remainder of our themes and the theoretical frameworks. Table 2 presents a summary of our frameworks and its correspondences to the remainder of the primary themes.

TABLE 2. Framework Summaries and Themes

framework	summary	primary themes
community of practice	building of community to support its participants	<ul style="list-style-type: none"> ▪ <i>Building of community</i> ▪ <i>Supports for enactment</i> ▪ <i>Supports for sustained implementation</i>

diffusion of innovations	supporting of all stages in the adoption of innovations	<ul style="list-style-type: none"> ▪ <i>Organization of curricula</i> ▪ <i>Testimonials of effectiveness</i>
leadership	enabling interactions toward a desirable future	<ul style="list-style-type: none"> ▪ <i>Dissemination by participants</i> ▪ <i>Distribution of leadership</i>

Following are examples of how the frameworks and themes support *empowerment of participants*.

In the community of practice framework, it is about the building of a community that supports its participants. Within this framework, three themes characterized by it include: *building of community*, *supports for enactment*, and *supports for sustained implementation*. These themes empower participants because they provide: (1) spaces for those who share a domain of interest to enact their practice (*building of community*), (2) resources to make that space possible (*supports for enactment*), and (3) resources to sustain their practice (*supports for sustained implementation*). Without the supports for a space where modelers can enact their practice, it is difficult for them to become more empowered and consequently, lead to difficulties in the effective dissemination of reform.

In the diffusion of innovations framework, the successful adoptions of innovations is dependent on developers making sure that each stage in the adoption of an innovation is supported. It is not enough that adopters know about the innovation, but they must also be provided the resources to observe success for themselves in utilizing the innovation. For instance, the encouragement of modifications to the curricula (*organization of curricula*) empowers teachers because it engenders ownership of the curricula. However, this empowerment through ownership would not be possible without the various supports from the CoP, such as providing space for teachers to enact their practices. The *testimonials of effectiveness* were also indicative of empowered teachers because of the observed positive results from the implementation of Modeling Instruction. Without support at each stage in the adoption of an innovation, participants may not be empowered, or have the resources, to continue using the innovation.

From the leadership framework, a key aspect of it is that effective leaders enable interactions with their organizations toward some desirable future. This is empowering for the organization because members are treated more like equals than followers. For instance, teachers are enabled to lead Modeling Instruction workshops (*dissemination by participants*) by the developers. As workshop leaders, modelers are part of the *distribution of leadership*. Those who take

advantage of the opportunities to be leaders within their communities are empowered because they have been enabled to do so.

CONCLUSION

Based on our analysis of the viewpoints of five participants who were extensively involved with the reform, it seems that the empowerment of participants played a significant role in the sustained dissemination and implementation of the reform. When teachers feel empowered, they are more likely to continue their implementation an innovation. Our next steps in this research include: (1) further refining the relationships between the themes and frameworks, (2) interviewing users of the reform, which may suggest links between the theoretical frameworks and/or the addition of new themes, and (3) exploring the dissemination of other research-based reforms to explore the effectiveness of reforms disseminated in the US at the K-12 level.

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