

# Physics Faculty and Educational Researchers: Divergent Expectations as Barriers to the Diffusion of Innovations

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**Abstract.** To identify barriers to the dissemination of innovative instructional strategies we conducted interviews with 5 physics instructors who represent likely users of educational research. One significant barrier appears to be that faculty and educational researchers have different expectations about how they should work together to improve student learning. This discrepancy was expressed directly (and often emotionally) by all of the instructors we interviewed. Although different instructors described different aspects of this discrepancy, we believe that they are all related to a single underlying issue: educational researchers expect to disseminate curricular innovations and have faculty adopt them with minimal changes while faculty expect researchers to work with them to adapt knowledge and materials for their unique instructional situations. We will explore this claim and the evidence found in the interview transcripts. We will also discuss implications for the educational research community.

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## INTRODUCTION

Physics Education Research (PER) practitioners have engaged in substantial curriculum development and dissemination work in recent years. Yet, it appears that this work has not had a significant influence on the basic teaching practices of typical physics faculty.

To better understand this situation, we conducted semi-structured exploratory interviews with a purposeful sample of five tenured physics faculty from four different institutions (one small liberal arts college, two regional universities, and one major research university). We selected non-PER faculty who had reputations for being particularly thoughtful and reflective teachers in introductory level physics. We expect faculty with these qualities to be more likely than average to be interested in educational research. Further details about these interviews as well as additional findings are available elsewhere [1,2]. In this paper we examine how these instructors used educational research in making instructional decisions and identify differences in expectations that appear to be barriers to fuller use of educational research.

Expectations, of course, are important in all human interactions and divergent expectations often result in conflict. For example, a student who expects to sit

passively in class is likely to be frustrated and resist an instructor who expects class to be interactive. Likewise, the instructor is likely to be frustrated by this resistance.

Divergent expectations are not the only factors preventing more rapid diffusion of educational innovations. In fact, they probably are not the most significant barriers [2]. They are, however, barriers over which the educational research community has significant control. Thus, we believe that it is quite useful to explore these expectations and implications for curriculum development and dissemination.

## THEORETICAL BASIS: ADOPTION-INVENTION CONTINUUM

One can think of the instructional change process as involving two types of participants. One type is instructors who are interested in or being asked to change their instruction. The other type, change agents, are curriculum developers or professional development providers who provide information, materials, encouragement, etc. to help the instructors change their instruction.

Based on the change literature [3-5] and our own work [6], we have developed four basic types of change that vary in terms of the roles of the external

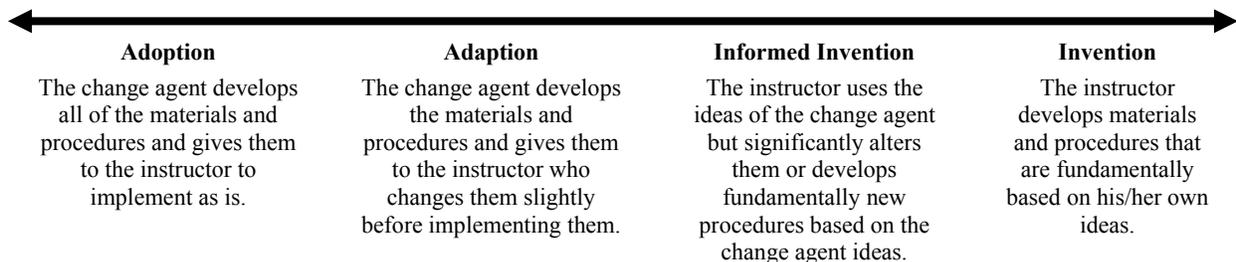
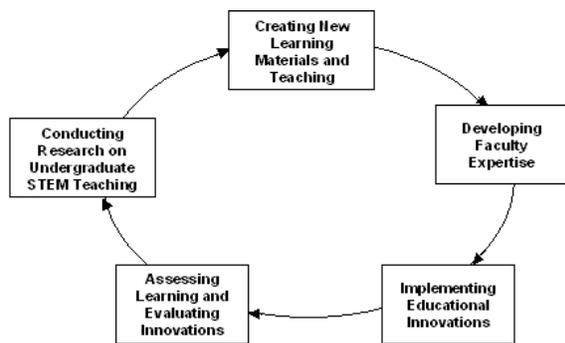


FIGURE 1. Adoption-Invention Continuum

change agent and the instructor (Figure 1). These are not discrete categories, but rather occur on a continuum. We have found it useful, however, to use these category labels to represent general locations along the continuum. At the adoption pole the change agent develops all of the materials and procedures and gives them to the instructor to implement as is. At the invention pole the instructor develops everything with minimal external influence.

### Change Agent Expectations

There are a wide variety of change agents with a wide variety of expectations. However, most change agents operate near the adoption/adaption end of the continuum. For example, the model of curriculum development and dissemination advocated by the NSF-CCLI program (Figure 2) clearly shows the change agent responsibilities for conducting research, developing materials and then helping faculty develop expertise in using these materials [7].



Cyclic model for knowledge production and improvement of practice in undergraduate STEM education

FIGURE 2. NSF-CCLI model of educational change.

There is nothing inherently wrong with this perspective. A change agent might imagine that the adoption model would be most effective since it places much of the burden on the change agent to develop innovative strategies and materials. This takes considerable time and expertise that typical faculty may not possess. It would be reasonable to assume that faculty expect this sort of interaction with educational researchers.

## ANALYSIS AND RESULTS

The change process for individuals generally includes three basic activities [3-5], (1) identifying an instructional problem, (2) becoming aware of a potential solution, and (3) implementing the solution. Thus, we can examine the extent to which each activity is accomplished and the interactions between instructor and change agent that facilitate or hinder each activity.

### Identifying problems with practice

All of the instructors felt that there were problems with their instruction that could, at least potentially, be improved via changes in their instructional practices. In most cases the instructors report that their interactions with educational researchers enhanced their belief in the importance of and their understanding of the instructional problems. For example, Mary describes “always” believing that students don’t get much from a traditional lecture and that class should be more interactive. Yet, describes not realizing the extent of the problem until giving the FCI: “*Just the fact that somebody can go through the entire class and still think that you needed a force to cause motion was an eye opener.*”

### Awareness of Research-Based Instructional Methods

These instructors were also aware of research-based instructional innovations that might be useful in solving their problems. Four of the five instructors were reasonably familiar with PER. They were aware of the names and basic practices involved with innovative curricula as well as a number of more general strategies. The fifth instructor (Gary), while not explicitly familiar with PER had been exposed to general research-based teaching techniques through a residential grant-sponsored program. Thus, these instructors appear to have a reasonable degree of knowledge about possible solutions to the instructional problems they face.

**TABLE 1.** Instructional innovations. A: Adoption, D: aDaption, N: iNformed Invention, I: Invention. Instructors were classified in the highest category (i.e. closest to adoption) possible based on the available evidence in the interviews.

Instructional Strategy	Terry	Harry	Mary	Gary	Barry
Peer Instruction	N	N	N	N	N
Physlets	D				D
“Army” method. Pose question, pause, call on student				N	
Discussion-based teaching techniques				N	
“Exercises” to help students through the steps involved in solving a problem				I	
Different instruction for different student abilities				I	
FCI/CSEM as an assessment instrument	A	A	A		
Modeling and discussing expert thinking related to problem solving			N		
Small group work		N	N		D
Solicits questions from students		I			
Lecture-based questions (posed to students after the lecture)					I

### Instructional Changes – Instructors Engage in Informed Invention

During the interview we asked the instructors to describe instructional changes that they had made and how their knowledge of educational research had influenced these changes, if at all. We were then able to classify each of these self-reported changes on the adoption-invention continuum (Table 1).

Half of the changes reported by the instructors fell in the informed invention category. This means that they generally agreed with PER on what the problems were and the general idea of the solutions, but did not take the complete PER solutions and implement them. They developed the details of the solution on their own.

As would be expected, if faculty develop the details of implementation on their own, some are likely to do so in a way that is consistent with current understanding of teaching/learning and others are likely to do so in a way that is inconsistent. For example, Terry described using Mazur’s Peer Instruction but without the peer interaction component, despite research suggesting this is an essential component.

### Mismatch in Expectations

It appears that curriculum is developed assuming adoption and adaptation, while what faculty really do and want is some degree of invention. The result of this mismatch can be frustrating for faculty. During the interviews it became apparent that these instructors had problems with the way in which PER practitioners disseminated results.

For example, faculty tended to see PER practitioners as not really interested in them or their

students, but rather as promoting a particular curriculum. Instructors described what they saw as this sales mentality of PER practitioners as making their interactions somewhat confrontational. *“The interactions between the two tend to be that the teacher is critical, the education researcher is trying to make a point, and a lot of time the conversation between the two, as soon as it hits a snag . . . they [educational researchers] hide behind what feels like a smoke screen and then that kinda ends it because you can’t argue with them.”* (Mary) Instructors also criticized PER practitioners as promoting their instructional package or technique with the expectation that it will work well in any environment, even ones quite different from the one in which it was developed.

In addition, these instructors saw educational researchers as sometimes insinuating that they are bad teachers. *“The first word out of their [a typical PER presenter] mouth is you’re not doing things right.”* (Terry) Additional details on these instructors’ perceptions of PER is found elsewhere [1].

### What do Faculty Want?

All five participants described an instructors’ personal style, preferences, skills, and teaching situation as being very important in determining appropriate teaching practices. Thus, they did not expect any instructional package created elsewhere to work well for them with minimal modifications and therefore did not follow the adoption model. They would like the PER community to recognize that they have valuable skills and experience and work with them to improve teaching and learning. *“I’ve spent my life doing this [teaching] and part of my teaching is in fact to be aware of all of the things that are going on, but I want it to be useful and meaningful to that*

discourse.” (Terry). This means, at a minimum, that change agents would communicate openly with them in a way that they can understand and use to shape their instruction. It also means that change agents would focus more on developing basic theory rather than specific curricular packages. “*I have a good feel for the conditions under which [optical phenomena] occurs . . . I don’t have an intellectual framework around which to organize innovations in teaching.*” . . . “*If I had a framework like that then I could answer my own questions [about teaching].*” (Harry)

## DISCUSSION

These faculty view PER as expecting the change agent-instructor interaction to follow the adoption model. Yet, they think that the most productive change agent-instructor interaction would be for PER and faculty to work together under the informed invention model. In practice, though, faculty tended to work alone reinventing. In some cases faculty reinvented instruction that was consistent with the original intention, but in many cases they reinvented instruction that was missing important fundamental features of the intended instruction. This isolation also meant that there was no sharing of successes or failures so that others could learn from them.

What faculty describe as the ideal case (PER-instructor interaction in developing instructional innovations that are consistent with unique instructor and local situations) can also be found in the literature as an effective instructional reform method in higher education [8-10].

## IMPLICATIONS

Standard dissemination often treats faculty the way traditional instruction treats students. Education research indicates that attempting to pass knowledge directly to students, rather than helping them construct their own understanding, is ineffective at promoting genuine learning. Change agents need to do with faculty what education research already advocates with students. PER should be a guide for faculty, drawing them into discussion and valuing their ideas, structuring dissemination around their needs and not our research products, encouraging them to collaborate with each other on teaching just as they do on research, and helping them become their own experts.

As the instructors note, PER is not currently well-suited to support faculty in this manner. It is well-suited to support adoption/adaption. Although care is warranted in making generalizations from this small study, the results suggest that in order to have a wider impact on physics faculty, the PER community should

consider ways to move closer to the invention side of the continuum. This would mean that the PER community would not focus their attention on describing deficiencies with traditional instructional practices, providing polished ready-to-use curricula, and having individuals promote only the curricula that they developed. Rather PER would focus on working with faculty as partners, either individually or in small groups to improve instructional practices in individual situations.

## ACKNOWLEDGEMENTS

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