

# Pedagogical Practices and Instructional Change of Physics Faculty

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## Abstract

We report initial results of a web survey of 722 physics faculty in the United States regarding their instructional practices. Survey responses indicate that faculty generally know about many physics education research (PER) products and are interested and motivated to try aspects of these products in their own teaching. However, self-reports of actual classroom practices indicate that the availability of these research-based products has not led to fundamental changes in instruction. Faculty report time as the biggest impediment to using more research-based methods. Results indicate a need for research-based dissemination that accounts for the complexity of instructional change.

## I. INTRODUCTION

Over the last several decades many research studies have been conducted to better understand the teaching and learning of introductory college level physics.<sup>1,2</sup> This extensive body of research has been used to develop a large number of curriculum and pedagogies which have been tested and shown to improve desired outcomes such as problem solving skills, conceptual understanding, and student attitudes.<sup>1,3</sup> Although a great deal of effort has been put into research, development and dissemination of ideas to improve college physics teaching, backed by funding from organizations such as the National Science Foundation and the U.S. Department of Education, the impact of these efforts on physics instruction is not well known. Further, there is no clear explanation for why many physics faculty do not use these research-based instructional practices.

In this paper we report on several aspects of a larger study conducted to better document the current state of college-level physics teaching in the United States and to learn more about when, why, and how physics faculty use research-based practices. Specifically, we focus on the following research questions:

1. What pedagogical practices do faculty report using?
2. Why do faculty not adopt more research-based practices?

## II. THEORETICAL BACKGROUND

This study was designed based largely on results of a smaller pilot study.<sup>4,5</sup> In the pilot study, we interviewed non-PER faculty who had attributes that made them ideal candidates for implementers of research-based strategies. Specifically they were senior (so tenure pressure should not be a factor and they had time to have learned about, tried and reflected upon multiple methods) and they were considered by their peers to be dedicated, thoughtful teachers who genuinely cared about their students.

Several themes emerged from the pilot study:

1. **Many common ideas about why research-based reforms are slow to integrate into mainstream teaching were found to be questionable.** Common explanations for the slow rate of adoption of research-based instruction include: faculty are focused on research and do not care about teaching, faculty are not aware of research-based innovations, and faculty are not convinced of the value of research-based innovations. None of these explanations were supported by our pilot study. Our interviewees were dedicated instructors who knew about many innovations and, for the most, part felt that the innovations have value. Yet, they still taught traditionally. Valuing good teaching and the products of physics education research may be necessary for research-based change, but it is not sufficient. (See Ref. <sup>4</sup> for a more complete discussion of this theme.)
2. **Situational characteristics of an instructor's environment play an important role in the nature of classroom instruction.** Dissemination efforts often assume that if an instructor knows about and believes in the value of an innovation then they will chose to implement it. However, evidence suggests that actions are a result of both individual and situational characteristics. It appears that many instructors may teach traditionally while holding beliefs that are more consistent with research-based instruction than with traditional instruction. We found evidence that situational characteristics play an important role in this mismatch (for example, an instructor wants to use methods which utilize extensive student-student interaction but is assigned a classroom with bolted down chairs). One implication is that dissemination efforts based solely on changing faculty beliefs are not likely to be successful. Faculty also need help identifying and overcoming common situational barriers. (See Ref. <sup>4</sup> for a more complete discussion of this theme.)
3. **Faculty often modify research-based instructional strategies.** It appears to be rare for an instructor to take a product from physics education research and implement it as is. Instructors are unique individuals with their own unique classroom settings and have a tendency to use research-based products to generate ideas as they develop their own approaches to teaching. Sometimes modifications are minor; often they are substantial. Additionally, it was clear from our interviews that faculty may misreport use of some practices. For example, they may report having a highly "interactive" classroom but upon further probing it is clear that there is little to no student-student interaction, little to no hands-on activities, and teacher-student interactions with only a small handful of students.<sup>6</sup> Evidence suggests that when modifications were made by faculty to research-based curricula and ideas that these modifications were most likely to be in the direction of making the innovation more in line with traditional instruction. (see Ref. <sup>5</sup> for a more complete discussion of this theme.).

Based on these results from interviews, we designed a survey to more fully document and understand what, how and why research-based innovations are integrated into mainstream physics teaching. Specifically, we included questions to further check the validity of common assumptions about educational change, probed for reasons for discontinuing use of strategies or failing to implement strategies that included environmental constraints as well as individual characteristics, asked about modifications to research-based strategies, and included questions to determine the extent to which

faculty were engaged in specific classroom practices prescribed by the research-based products they claimed to be using.

### III. STUDY DESIGN

A web-based survey was developed and administered to a national sample of physics faculty from three different types of institutions. Full details of the survey design and implementation, as well as the complete survey, are reported in separate paper.<sup>7</sup>

The final survey consisted of 61 questions. Demographic information was collected (years teaching, rank, employment status, gender, type of institution, etc.) as well as information about the courses the faculty member taught (calculus or algebra based, class size, structure of labs and recitation, number of sections, etc.). The majority of the survey focused on collecting information about the participant's knowledge and use of 24 specific research-based strategies that have been developed and disseminated in recent years. Finally, participants were asked general questions about their teaching goals and practices.

The survey was administered in Fall 2008 by the American Physical Society Statistical Research Center (SRC). Over 2000 faculty at randomly-selected institutions were asked to complete the survey. The response rate was 50.3% and yielded 722 useable responses (unuseable responses were due to non-completion, failure to provide informed consent, or failure to meet criteria for inclusion such as having recently taught an introductory course). Demographics of the final sample are provided in Table I.

Type of Institution	Academic Rank	Gender	Semesters Taught
Two-Year College 25.8%	Lecturer 7%	Male 83%	1-4 Semesters 15%
Four-Year College (BA) 35.3%	Assistant Professor 20.8%	Female 17%	5-10 Semesters 20%
Four-Year College (With graduate program) 38.9%	Associate Professor 24.2%		>10 Semesters 65%
	Full Professor 35.6%		
	Other Rank 12.3%		

Table I – Demographic Characteristics of survey respondents by type of institution, academic rank, gender and semesters of teaching an introductory course.

### IV. FINDINGS –WHAT PEDAGOGICAL PRACTICES DO FACULTY REPORT USING?

Although a great deal of time and money has been spent developing and disseminating research-based curricula and pedagogies, the extent to which these efforts have made their way into mainstream physics teaching had not been documented. The first goal of our study was to document the extent to which research-based practices have made their way into mainstream physics teaching. After all, if dissemination efforts are already successful at changing instructional practice, then there is no need to further study the issue.

Survey participants were presented with a list of 24 specific research-based instructional strategies and asked about their level of knowledge about and use of each strategy. Follow up questions then probed the extent to which strategies were modified when used and reasons for discontinuing use. A full

reporting of this data is provided in another paper, including data specific to each strategy included in the survey.<sup>7</sup> The results are summarized below.

### *A. Do faculty know about research based innovations?*

- 87% of respondents reported familiarity with at least one of the 24 strategies.
- Approximately half (49%) of respondents reported familiarity with more than five of the strategies.
- The strategy faculty have the most awareness of was Peer Instruction,<sup>8</sup> with 64% of faculty reporting familiarity.
- Eight of the strategies (Peer Instruction, Physlets,<sup>9,10</sup> Cooperative Group Problem Solving,<sup>11,12</sup> Workshop Physics,<sup>13,14</sup> Just in Time Teaching,<sup>15</sup> Tutorials in Introductory Physics,<sup>16</sup> Interactive Lecture Demonstrations,<sup>17</sup> and Activity Based Physics Tutorials<sup>18</sup>) were familiar to more than 40% of the faculty surveyed.

While there is room for improvement, our data indicates that dissemination efforts have been reasonably successful in terms of generating faculty awareness of the existence of research-based innovations. The majority of faculty are aware of at least some research-based innovations. Of course, awareness of a particular strategy is only the first step. If faculty know of an innovation but do not use it then the dissemination effort is not successful.

### *B. Do faculty use research based innovations?*

Nearly half (48%) of respondents reported that they currently use at least one strategy. At first glance this appears to be a very positive result as it indicates that not only are faculty aware of innovations but large numbers of faculty are willing to try these innovations. However, some caution is in order. In our data, there is evidence to indicate that when faculty report using a strategy, actual classroom behavior is often inconsistent with that strategy.

As an example, consider the strategy of Peer Instruction. Peer Instruction was the most widely known (64% of instructors) and the most highly used strategy (29% of instructors). Among those instructors who reported using Peer Instruction, 41% indicated that they “used some of the ideas, but made significant modifications” and 6% indicated that they were “not familiar enough with the developer’s description” to indicate the extent to which they modified the strategy in their own use. So, nearly half of all respondents indicating that they used Peer Instruction, also indicated that they did not use it in a way that is consistent with the method developed by the researchers and demonstrated to be effective.

It is, of course, possible to modify a strategy while still maintaining or even improving its effectiveness. It is unreasonable to assume that any method can be developed and used in the same exact form in every environment. However, if extensive modifications are being made then the type and extent of those modifications need to be considered, since there is a real possibility that one or more components essential to student learning may be eliminated. In the survey, we asked a series of questions which

allow us to make some inferences about the actual classroom behaviors of faculty reporting use of Peer Instruction.

Peer Instruction, as reported by the developers, has several important components,<sup>8,19</sup> which include: the use of traditional lecture interspersed by the posing of conceptual questions, student-student discussion about their ideas, whole class voting, and conceptual questions on exams. Table II shows the percent of instructors who reported being current users of Peer Instruction and who also reported specific classroom behaviors.

Notice that the majority of Peer Instruction “users” are not incorporating many of the non-traditional components of Peer Instruction that the developers argue are important to the success of the method.<sup>8,19</sup> These faculty appear to be using instructional strategies that may be related to or inspired by Peer Instruction, but that have not been rigorously tested for efficacy.

	Percentage of Respondents
<b>Students discuss ideas in small groups (multiple times every class)</b>	27
<b>Students solve/discuss qualitative/conceptual problem (multiple times every class)</b>	27
<b>Whole class voting (multiple times every class)</b>	38
<b>Conceptual questions (used on all tests)</b>	64

*Table II – Percent of respondents who indicated they used Peer Instruction who also self-report using specific classroom practices consistent with Peer Instruction.*

Therefore, although faculty do report using many of the products of education research, caution should be taken when interpreting this result as it does not necessarily mean that classroom practices are consistent with what the research literature would suggest is necessary for improved student learning. The extent to which research-based innovations are modified and the kinds of modifications made appear to be an important aspect to consider when evaluating the impact of dissemination efforts.

### *C. What general classroom practices do faculty report using?*

There is no one way to teach physics that is effective for all students and faculty in all situations. It is reasonable to expect faculty to use ideas from research and adapt them to their own personalities and local environments. However, some characteristics of teaching are known to be more effective than others. In particular, there are several general characteristics common to most of the research-based strategies: they involve student-student interaction, they place importance on conceptual understanding, they encourage higher level thinking over rote learning, and they encourage active learning over passive learning. Additionally, low performance on measures of student learning are consistently associated with passive classroom activities such as traditional lecturing.<sup>20,21</sup> We asked a

series of questions about general classroom practices in order to gauge the extent to which faculty are engaging in activities commonly associated with more positive or negative student learning outcomes.

Respondents were asked “In the “lecture portion” of your introductory course, please estimate the percentage of class time spent on student activities, questions, and discussion”. Results are presented in Figure I and show a strong tendency against including many of these types of activities as a significant portion of the course.

We are not aware of any research indicating the optimal amount of time spent on student activities, questions, and discussions. However, Redish presents data to support his claim that full interactive strategies (such as workshop physics) can produce substantially better FCI gains than moderate active-engagement strategies (such as Tutorials in Introductory Physics or Cooperative Group Problem Solving).<sup>1</sup> Based on timing suggested by Mazur,<sup>8</sup> we estimate that a moderate active-engagement strategy such as Peer Instruction would result in approximately 20% of class time spent on student activities, questions, and discussion.

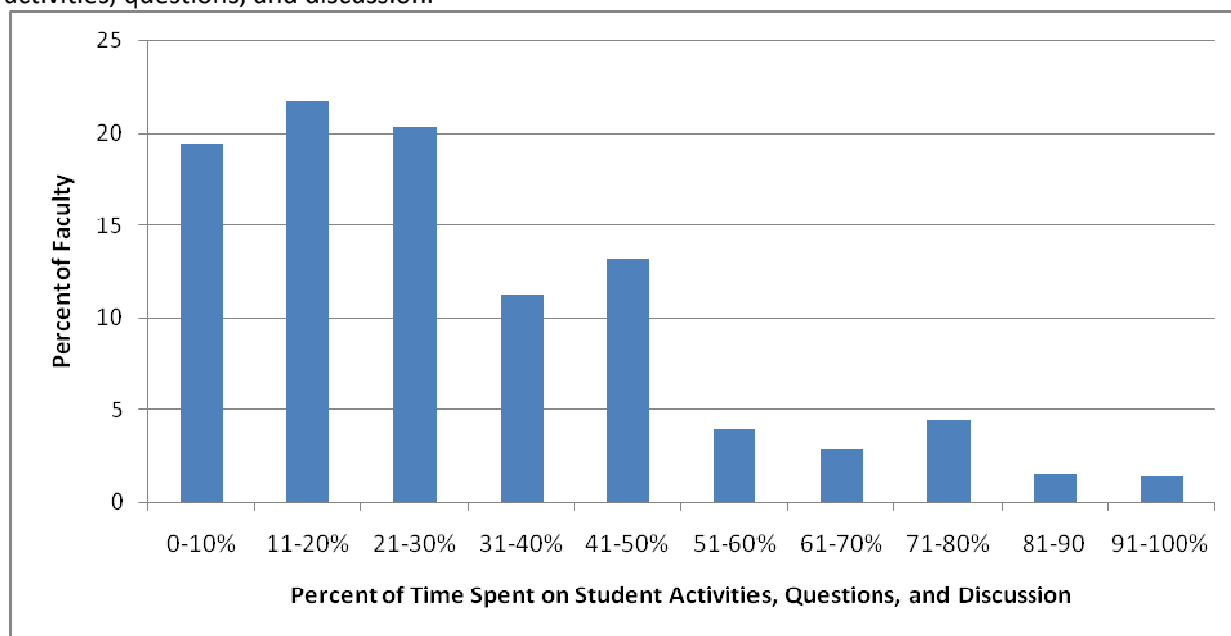


Figure I – Percent of class time faculty report spending on student activities, questions and discussion.

Respondents were then asked “In thinking about the LAST time you taught an introductory algebra- or calculus-based course...How frequently did you use these strategies in the lecture portion of the course?” A list of strategies then followed with multiple choice answers. The percent of faculty reporting each level of use is shown in Table III.

	Never	Once or Twice	Several Times	Weekly	For Nearly Every Class	Multiple Times Every Class
<b>Traditional Lecture</b>	4%	4%	6%	16%	48%	22%
<b>Students Discuss Ideas in Small Groups</b>	25	14	12	19	17	13
<b>Students design experiments/activities</b>	63	19	10	7	1	0
<b>Students required to work together</b>	25	10	16	22	15	12
<b>Instructor solves/discusses quantitative/mathematical problem</b>	1	2	9	23	43	24
<b>Instructor solves/discusses qualitative/conceptual problem</b>	1	3	8	20	45	22
<b>Students solve/discuss quantitative/mathematical problem</b>	12	10	18	25	25	10
<b>Students solve/discuss qualitative/conceptual problem</b>	11	9	15	23	28	14
<b>Whole class voting</b>	22	9	18	14	18	19

*Table III – Faculty reports of use of specific classroom practices.*

Only three of the methods listed do not require student involvement, these are focused primarily on the actions of the instructor (traditional lecture, instructor solves/discusses quantitative/mathematical problem, and instructor solves/discusses qualitative/conceptual problem). Strikingly, the top three most used methods are these three methods that allow students to remain relatively passive. Similarly, the method which gives students the most autonomy (Students design experiments/activities) is the least used.

From an educational standpoint, this is discouraging. Research has consistently demonstrated that students learn more when they are active and engaged. However, it appears that most instruction is still primarily such that the instructor is active while students are allowed to be passive.

We also asked about practices on tests and quizzes. The percent of faculty indicating each level of use is reported in Table IV.

	Never Used on Tests	Used Occasionally on Tests	Used Frequently on Tests	Used on All Tests
Well-defined quantitative problems	2%	6%	23%	69%
Open-ended quantitative problems	59	30	8	3
Novel problems	22	45	23	10
Multiple choice questions	34	21	17	29
Conceptual questions	7	22	26	45
Questions that require students to explain their reasoning	16	30	24	30

Table IV – Faculty reports of use of specific types of questions and problems on tests.

Not surprising, the most common element on exams is the well defined quantitative problem which often lends itself to a plug-n-chug solution approach. Questions which are open-ended and/or require higher level thinking skills are less likely to be used. Interestingly, another type of question advocated by physics education research, conceptual question, does appear to be used by a reasonable percentage of faculty. If the goal of physics instruction is to help students become better problem solvers and to develop higher level thinking skills then the result that exams often fail to assess these skills is discouraging.

#### D. Discussion

It appears that current dissemination efforts are successful at “getting the word out” and motivating faculty to try innovations. In general, faculty report knowing about research-based innovations. Additionally many faculty attempt to use these innovations in their classrooms. However, our survey data indicates that despite knowing about innovations and being willing to use ideas from the innovations in their teaching, to a large extent actual teaching practices are still traditional and not particularly consistent with practices demonstrated to improve student learning outcomes.

### V. FINDINGS – WHY DO FACULTY NOT ADOPT MORE RESEARCH-BASED IDEAS?

As discussed in the introduction, very little is known or understood about how or why physics faculty come to use ideas from PER despite extensive research, development and dissemination efforts undertaken in the field over the last several decades. In this section, we explore why research ideas have not had a greater impact on mainstream teaching.

#### A. Are faculty interested in change?

One possible hypothesis is that faculty are not interested in changing. However, our data indicates this is not the case. When we asked participants if they were interested in using more research-based strategies, 70% responded yes (see Figure II). Notice that this percentage is somewhat lower for faculty at institutions offering a graduate degree in physics, but it still includes the majority of faculty.

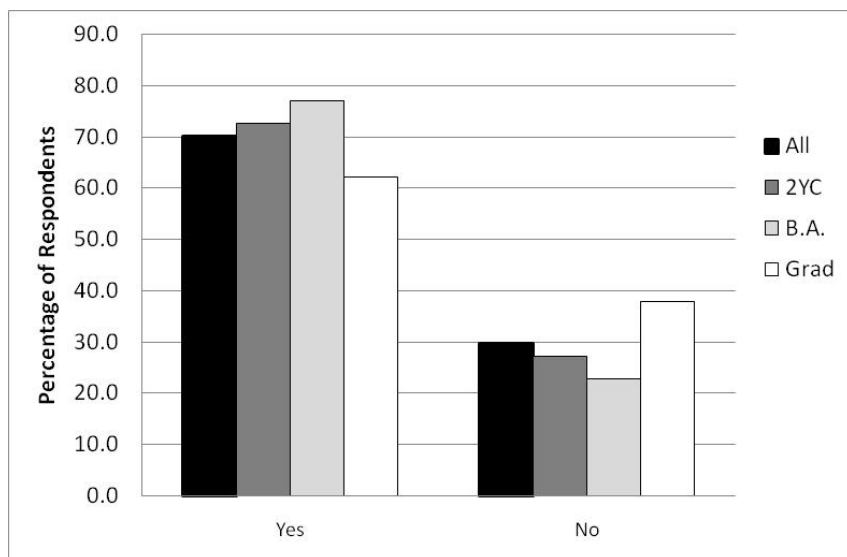


Figure II: Responses to the question “Are you interested in using more of the kinds of instructional strategies addressed in the previous questions?”.

Additionally, we found that when faculty were aware of an innovation they often tried it. For example, 68% of all faculty who reported being aware of Peer Instruction had tried it. Likewise, faculty with knowledge of a strategy reported being a user or former user at least 50% of the time for the following strategies: Ranking Tasks (66%), Cooperative Group Problem Solving (61%), Interactive Lecture Demonstrations (52%), and Physlets (50%). So, it appears that faculty are generally interested in change.

### B. Are Faculty Motivated to Change?

*External Motivation:* When asked, 92% of faculty report that their department is either very encouraging or somewhat encouraging about efforts to improve instruction. On the surface, this appears to be a very positive result. However, it should also be noted that when those who responded that they were interested in using more research-based strategies were asked why they did not do so, a significant number gave a response indicative of not having solid support from their department (see below for a more complete discussion of the reasons faculty list for not using more research-based strategies).

The reason for this discrepancy is somewhat unclear. One possible explanation is that departments may be more encouraging in a theoretical sense (i.e. they say they want to improve teaching which leads faculty to report feeling encouraged to do so) and less encouraging in practical ways (i.e. they fail to provide time and/or resources necessary to make changes). This is an interesting discrepancy which warrants further study. However, it does appear that most faculty find themselves in departments where they believe change toward improved teaching is encouraged.

*Internal Motivation:* In order to gain some understanding of the extent to which faculty may be internally motivated to change instruction, we asked respondents to rate the importance of the instructional goals of problem solving, conceptual understanding and attitude and appreciation of

physics. These are instructional goals commonly mentioned by the developers of research-based instructional strategies. We then followed up by asking them to rate the extent to which they were satisfied their instruction was reaching each goal. The results are shown in Table V below.

	<b>Respondents rating goal as very important</b>	<b>Respondents who rated the goal as very important who are extremely or somewhat satisfied with extent to which students are meeting the goal.</b>
<b>Problem Solving</b>	90%	73%
<b>Conceptual Understanding</b>	92	70
<b>Attitudes and Appreciation</b>	51	54.9

*Table V: Percent of faculty indicating the importance of instruction goals and their satisfaction with reaching goal.*

Traditionally, physics instruction has focused on problem solving. One of the major themes of physics education research has been to demonstrate that students can learn to solve difficult and complicated problems while still maintaining only a weak understanding of the basic underlying concepts.<sup>22,23</sup> Therefore, most of the research-based products have a strong focus on the development of conceptual understanding. The finding that faculty rate the goals of problem solving and conceptual understanding approximately the same is a positive result and indicates that faculty are likely to be receptive to most of the kinds of innovations promoted by physics education researchers.

However, underlying many of the research based innovations is the belief that students' attitudes are important and interplay with other factors to effect success on other course goals (such as problem solving and conceptual understanding). Interestingly, faculty often did not view attitudes and appreciation of physics as being a very important goal (though only 3% rated it as not at all important). This finding indicates that faculty may not be receptive to research-based curriculum that focus on student attitudes and that when using research-based curriculum they may be susceptible to modifying or disregarding components that focus on student attitudes.

While faculty do appear to generally share goals that are consistent with research-based reforms they also appear to be generally satisfied that they are reaching these goals. If someone is satisfied with the extent to which they are reaching a goal then they are presumably less likely to be interested in changing what they are doing. So, the high level of satisfaction faculty report indicates they may not be completely open to innovation.

However, it should be noted that despite reporting high levels of satisfaction, faculty also report high levels of willingness to try more research-based innovations. The reasons for this apparent discrepancy are unclear.

It appears that faculty are reasonably motivated to integrate research-based products in their own teaching. There is evidence of both external and internal motivation. Additionally, many faculty attempt to integrate these products into their instruction, which is further direct evidence of knowledge and motivation. Data from our survey indicate that it is neither lack of knowledge nor motivation which generally limits the integration of research-based strategies in mainstream teaching.

### C. What reasons do faculty give for not using more research-based innovations?

For the 70% of respondents who said that they were interested in using more research based instructional strategies, they were given a text box and asked “What prevents you from using more of these strategies?” Most (91.6%) of respondents wrote something in the text box. A summary of the responses as categorized by the authors is given in Table VI.

<b>TIME</b>	
Time to learn about and implement changes	28.6%
Time (not elaborated)	24.1
<b>LACK OF KNOWLEDGE ABOUT/ ACCESS to RBIS</b>	
Lack of familiarity with many RBIS	22.4
Lack of access to RBIS	3.1
<b>WEAKNESSES OF RBIS</b>	
Difficult to cover material (uses too much class time)	8.0
Not convinced of benefit	6.6
Requires too much instructor time to use	2.4
Student resistance (real or perceived)	2.1
Lack of ready-to-use materials	0.7
<b>LACK OF MOTIVATION TO ADOPT RBIS (other than TIME)</b>	
I don't follow one method, but adapt pieces of many to fit my teaching style.	6.1
Nothing	1.9
Inertia	1.2
<b>LACK OF FIT WITH DEPARTMENT OR INSTITUTION</b>	
Cost to implement (e.g., lab equipment, additional staff)	4.0
Need to coordinate changes with colleagues	3.8
Lack of appropriate classroom space/class scheduling	3.7
Cost (not elaborated)	2.6
Colleagues would not approve	2.1
Cost for students (e.g., books, clickers)	0.7
<b>UNCLEAR</b>	
Unclear response	4.7

Table VI: Categorization of responses to the question “What prevents you from using more research-based instructional strategies?” Percent of respondents providing an open-ended response indicating each reason is reported.

By far the most common reason mentioned was a lack of time (mentioned by 52.7% of those answering the question). In some cases it was clear from the responses that the respondent was referring to the

extra time it would require to learn about a strategy and then effectively implement the changes. For example, comments included:

- “Time constraints in researching different techniques and integrating them into the course.” (a two-year college instructor)
- “Time for investigating the different systems and then implementing them into my particular course.” (a B.A. instructor)
- “a lack of time to get acquainted with the methods and develop the course.” (a Grad instructor)

In other cases, though, the respondent did not explain what the time was for, often writing the single word “time” in the response box. In both cases, some respondents would elaborate about heavy teaching, research, or administrative duties that compete for their time.

The second most common reason for not using more research-based strategies was a lack of familiarity with them. For example, comments included:

- “lack of knowledge about any of them” (a two-year college instructor)
- “Ignorance. I have never heard of most of these strategies.” (a B.A. Instructor)
- “I have never heard of any of them.” (a Grad instructor)

Other concerns mentioned by much smaller percentages of faculty were grouped into categories of : weaknesses of strategy, lack of motivation to adopt strategy, and lack of fit with department or institution. We were unable to understand and categorize a small percentage (4.7%) of the responses.

#### *D. Discussion*

Whether or not a known innovation is adopted depends on factors unique to an individual (beliefs, motivations, knowledge, etc) as well as environmental factors. Survey results indicate that to a large extent the individual characteristics of faculty necessary for change are present. Most faculty report that they are interested in and motivated to improve their instruction. However, faculty often report some environmental conditions that are not supportive of change; in particular the lack of time to learn about and implement changes.

“Time” was the number one reason faculty gave for not using more research-based strategies. While the lack of time is a real hindrance, we hesitate to conclude that with more time, instructors would implement more research-based strategies. We believe there are likely more complicated reasons underlying these instructors feeling that lack of time prevents them from using more strategies. For example, faculty often spend a great deal of time preparing detailed lecture notes and presentations, even to the detriment of other job responsibilities.<sup>24</sup> Instructors will exert significant effort developing and changing instruction, but that effort may or may not be in the direction of research-based changes. So to what extent is “time” really the issue? If faculty are feeling frustrated, confused, or unsure about implementing a strategy, they may have a tendency to say “I don’t have the time.” More follow-up is needed to understand the reasons behind the perceived lack of time. We are in the process of

investigating this issue more extensively with individual interviews and hope to provide more insights in a future paper.

## VI. CONCLUSION

It appears that in some respects, dissemination efforts in physics education have been successful. While improvements could be made, faculty are often aware of research-based innovations and are willing to try them. However, two areas appear to be limiting substantial and sustained changes in classroom practice. First, faculty usually modify strategies, often modifying out essential components (such as student-student interaction). Secondly, faculty report work environments that do not allow them to invest the time required to make a major instructional change. Thus, it appears that while faculty report high levels of departmental-level encouragement to improve teaching, they also report that they are not given the time necessary to make those improvements. This is an indication that there is desire in individuals (both faculty and administrators) to improve teaching using research-based strategies but that other aspects of the work environment may impede that desire.

Over the last several decades, the field of physics education research has matured substantially. Gone are the days of “I tried this in my classroom and it seemed to work”. Curriculum development is now frequently based on extensive teaching/learning theory along with rigorous testing and evaluation. However, the field has not generally taken this research-based approach to dissemination. The approach to dissemination is typically unarticulated and untested. For example, in a review of journal articles reporting on efforts to disseminate new instructional strategies, Henderson et. al. found that a significant number of studies do not report a specific change strategy or offer evidence of success or failure of change efforts.<sup>25</sup>

Typically, dissemination involves informing faculty of the research-based innovation, convincing them of the need for the innovation, and providing them with new curricular materials. While this model is intuitive, it is not based on data and has not been shown to be effective. The results of our study indicate that this dissemination model may successfully increase awareness of both the innovation and the need for the innovation, and may also encourage faculty to try the innovation. However, there is a gap between a faculty member deciding to try something and the innovation being successfully integrated into their instruction. The typical dissemination model of developing and distributing materials assumes that once a faculty member is convinced to try something that the innovation has been successfully disseminated. However, this is not the case since faculty often significantly modify and/or discontinue use of an innovation. While the inform/convince/distribute strategy appears successful at generating initial knowledge and interest in change, it has not resulted in large changes in actual classroom practice. A model that accounts for the complexity of real classroom change is needed.

Based on our results, this model should address the high level of modifications currently being made (what are the reasons behind these modifications and how can faculty be supported to make effective modifications?) as well as external constraints faculty face when attempting to integrate research-based strategies (how can barriers be recognized and overcome?). Promoting change in instructional practices is complicated and poorly understood. It would benefit from the same careful research-based focus that has been given to the development of effective curriculum and pedagogies.

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