Pedagogical Practices of Physics Faculty in the USA

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Abstract. During the Fall of 2008 a web survey, designed to collect information about pedagogical knowledge and practices, was completed by a representative sample of 722 physics faculty across the United States. This paper presents results partial results from the survey. Specific teaching practices reported to be used by faculty are summarized. These self-reports indicate that the majority of physics teaching is not consistent with many results supported by educational research, such as the use of instruction that promotes active learning. Reasons why faculty do not use more research-based practices are explored.

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INTRODUCTION

Over the last several decades a great deal of research has been conducted to better understand the teaching and learning of introductory college level physics. Additionally, this extensive body of research has been used to develop a large number of curricula and pedagogies which have been tested and shown to improve desired outcomes such as problem solving skills, conceptual understanding, and student attitudes. 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 Department of Education, anecdotal evidence indicates that the impact of this effort on mainstream physics teaching has been minimal. Further, there is little understanding of why mainstream physics teaching has not been impacted to a greater extent.

In order to understand more about how, when, and why faculty come to use research-based pedagogies, we surveyed a representative sample of physics faculty. In this paper we report findings from that survey to address two specific questions:

1. What general instructional practices do physics faculty use.

2. Why don't physics faculty use more research-based instructional strategies?

METHODS

A web-based survey was developed and administered to a national sample of physics faculty from three different types of institutions: two-year colleges, four-year colleges with a bachelor's degree as the highest physics degree, and four-year colleges with a physics graduate degree.

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 a particular course the faculty member had taught recently (for example, 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. Finally, participants were asked general questions about their teaching goals and practices.

The survey was administered in the Fall of 2008 by the American Physical Society Statistical Research Center (SRC). The results presented here represent the 722 useable responses (a 50.3% response rate).

RESULTS

As reported more fully in a companion paper [1], 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. A large majority (87%) reported familiarity with at least one of the strategies and half (50%) reported familiarity with more than five of the strategies. Further, nearly half (48%) reported that they currently use as least one strategy.

While there is room for improvement, our data indicates that dissemination efforts have been reasonably successful in terms of generating faculty awareness and interest in the existence of research based innovations.

However there are indications that faculty often fail to implement innovations in a way that is consistent with improved outcomes. For example, when asked about specific classroom behaviors (such as the use of student-student discussion) the majority of self reported users of Peer Instruction[2] do not report behaviors consistent with Peer Instruction[1].

What 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 levels of learning outcomes are consistently associated instructional practices that allow students to be passive, such as excessive lecturing.

The survey 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 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". The average of all answers was 32% with a standard deviation of 22%. This is an indication that most of the time, in most classes, students are not required to interact.

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 1.

Only three of the methods listed do not require student involvement, they are focused on the actions of the instructor (traditional lecture, instructors solves/discusses quantitative/mathematical problem, and instructor solves/discusses quantitative/ mathematical problem). Strikingly, the top three most used methods are these three methods in which it is the instructor who is active. And, 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 need to be active and engaged in order to learn. However, it appears that most instruction primarily consists of an active instructor and passive students.

The survey also asked about practices on tests and quizzes. The percent of faculty indicating each level of use is reported in Table 2.

The most common type of question used on exams are well-defined quantitative problems. These, of course, often result in students using a plug-n-chug solution approach. Questions which are open-ended and/or require higher level thinking skills are less likely to be used. These are types of questions commonly advocated by physics education researchers. Interestingly, another type of question advocated by physics education research, conceptual question, does appear to be used by a reasonable percentage of faculty.

Why do Faculty Not Use More Research Based Practices?

There are a lot of possible reasons why faculty might not use instructional strategies advocated by research. Survey questions were designed to help support or refute several common explanations for change or lack of change. As reported earlier, faculty are often aware of research-based ideas. Further they are interested in using them. When asked, 70% said they were interested in using more research based strategies. Additionally, faculty are often willing to try an innovation when they were aware of it. For example, 70% of those aware of Peer Instruction had tried it.

Another possible explanation for limited use of research-based strategies is that faculty may not feel supported by their department to integrate research-based changes. However, the majority (92%) of faculty report that their department is either very encouraging or somewhat encouraging about efforts to improve instruction.

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

Table 1. Percentage of Faculty Reporting Use of a Particular Teaching Strategy

	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 2. Percentage of Faculty Reporting Use of Type of Test Question

Additionally, faculty generally report goals consistent with research-based reforms and some level of dissatisfaction with the extent to which they were reaching those goals (see Table 3). This indicates that faculty are likely to be motivated to implement research-based practices.

	Goal is "very important"	"extremely or somewhat satisfied" with extent goal reached
Problem Solving	90%	72%
Conceptual Understanding	92	69
Attitudes and Appreciation	51	47

Table 3. Percentage of faculty indicating importance of goal and satisfaction of goal reached.

If faculty are aware of research based innovations and motivated to try them, why do we not see higher levels of use? 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 below in Table 4.

By far the most common reasons 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. Sample 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)

TIME	
Time to learn about and implement changes	28.6%
Time (not elaborated)	24.1
LACK OF KNOWLEDGE ABOUT/ ACCESS to RBIS	
Lack of familiarity with many RBIS	22.4
Lack of access to RBIS	3.1
WEAKNESSES OF RBIS	
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
LACK OF MOTIVATION TO ADOPT RBIS (other than TIME)	
I don't follow one method, but adapt pieces of many to fit my teaching style.	6.1
Nothing	1.9
Inertia	1.2
LACK OF FIT WITH DEPARTMENT OR INSTITUTION	
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
UNCLEAR	
Unclear response	4.7

Table 4. Percent of faculty indicating a particular reason for not using more research-based strategies.

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.

DISCUSSION AND CONCLUSIONS

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 engage in 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 ideas but that other aspects of the work environment impede that desire.

Dissemination is often undertaken without a clearly articulated change strategy. The unarticulated strategy often involves informing faculty of new ideas and then making curriculum available. While this strategy appears successful at generating 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 in need of development.

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 ideas (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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