

Physics Teacher Characteristics and Classroom Practices

Melissa S. Taylor and Jeffrey A. Phillips

Department of Physics, Loyola Marymount University, Los Angeles, CA 90045, USA

Abstract. One hundred eighteen high school and college teachers in Southern California completed a web-based survey designed to better understand the differences in physics classrooms and the reasons behind the teachers' choices. Survey topics included teachers' familiarity and use of research-based instructional strategies, amount of student-student interaction in their classes, their views about teaching and their interactions with the physics teaching community. Partial results from the survey are presented in this paper. Among the findings was that while increased interactions with colleagues correlated with more student-student interactions, increased participation in conferences or reading of journals related to physics teaching did not.

Keywords: teaching methods, introductory course, teacher attitudes

PACS: 1.40.Di, 01.40.Fk, 01.40.G-, 01.40.J-

INTRODUCTION

Physics education researchers have documented barriers to student learning in introductory classes and strategies to overcoming these barriers. These facilitators often are in the form of published instructional methods and/ or classroom materials. They may involve whole course revision, or target specific aspects such as lecture, lab or recitation. Additionally, assessment tools have been developed to help instructors and students identify strengths and weaknesses.

While many successful research-based instructional strategies (RBIS) have been developed, there is still a concern that instructors are not readily adopting them. Previous studies have documented that among college instructors, nearly half say they use at least one RBIS and 87% are familiar with at least one. [1]

One concern regarding the adoption rate is the way that instructors are learning about the RBIS. How does attending physics education conferences or reading physics education journals impact instructors' likelihood to use RBIS? Instead, do daily interactions with colleagues provide more of an impetus to use or not use RBIS? [2]

A second issue with facilitating student learning is what happens in the classroom, aside from any proper name that instructors want to employ when describing their teaching. Do the instructors employ methods that have significant student-student interactions? Are there correlations between greater conference

attendance and journal reading and increased student-student interactions?

In addition to looking for connections between classroom practices and social interactions, this study looks at instructors' motivation, self-regulation, views of intelligence (incremental versus entity) and views of learning (constructivism).

Much of the previous work on familiarity and usage of research based instructional strategies has focused on college instructors exclusively. High school physics classes represent an equally important constriction in the STEM pipeline. In this study, both populations of instructors were surveyed.

METHODS

High school, two-year college and four-year college physics instructors throughout Southern California were invited to complete a web-based survey. Invitations were distributed via the AAPT section listserv, which had approximately 600 subscribers at the time of the survey, as well as emailed directly to approximately 250 two-year and four-year instructors who were listed as instructors of record within the previous academic year.

Responses were voluntary and anonymous, except for those who included their email address for possible follow-up. The only compensation that respondents were offered was the opportunity to enter their name on a separate list that was used to randomly select five winners of \$50 gift certificates. One hundred eighteen completed the survey.

The survey consisted of ninety-nine items, which were divided between instructor demographic characteristics, familiarity and usage of research-based instructional strategies, description of classroom practices, frequency of interactions with other teachers and researchers and beliefs about teaching and learning.

Personal opinion and belief items were either framed as a five-point Likert scale or a five-point scale akin to a semantic differential scale, where respondents were asked to place themselves on a continuum between two opposite words or phrases. In most of the analysis, the five-point scales were collapsed into a three-point one. For example, *strongly disagree* and *disagree* were treated as equivalent in the analysis.

Respondents were never forced to respond to an item, they were always allowed to skip forward. There was no time constraint on completing the survey and respondents were allowed to resume where they left off at a later date. Among those who completed the survey on the same day that they began, the average time for completion was under twenty minutes.

RESULTS

Instructors were asked to base their responses on an introductory, general, honors or AP physics course that they had taught within the past two years. In addition to characterizing these physics classes, survey items allow us to explore correlations between the instructional methods and how respondents interact with other instructors as well as their intrinsic interest in improving their teaching.

Population Description

Sixty-three high school instructors and fifty-five college instructors completed the survey. For both groups, 22% taught at public institutions, with the remainder at private institutions. Among the college instructors, two-year colleges, primarily undergraduate institutions, comprehensive universities and Ph.D. granting universities were represented.

The majority of respondents indicated that their highest academic degree was in physics; although, as shown in table 1, the high school instructors' degrees were divided across a diverse set of disciplines. The survey did not inquire what field(s) the instructors' other degrees were in, so it is possible that many of the high school teachers do have a physics background, even if they have since studied other disciplines. The distribution of high school teacher degrees is comparable to what has been previously been documented in national studies. [3] Table 2 shows the

TABLE 1. Educational background of respondents

	High School	College
Highest degree	Instructors	Instructors
Bachelor	27%	0
Master	62%	24%
Doctorate	10%	76%
Discipline		
Physics	30%	87%
Education	30%	0
Chemistry	13%	0
Engineering	10%	0
Astronomy or Astrophysics	0	9%
Mathematics	5%	4%

number of years teaching experience for the high school and college instructors.

The classroom size for the high school teachers was rather homogenous, 30 ± 11 students. The average college class size was 54 students, but they ranged from 10 students to 288 students, with 20% being larger than 50 students.

Questions that asked instructors to identify their familiarity and usage of various instructional strategies can be used to compare this sample to ones that have been studied before. The thirty-four instructional strategies were separated into six categories: whole course, lecture, lab, recitation, text and assessment. The categories were patterned after similar ones developed by Henderson [4] and Redish [5]. The assessment category consisted of research based content and attitude surveys. For each of the items, instructors were asked whether they had encountered it once, multiple times, never or were experienced enough to lead encounters about it. An "encounter" was defined for the instructors as having watched it in action, conversed with a colleague who is experienced with the item, attended a seminar presentation or read a journal article.

Table 3 shows the familiarity of college instructors with some of the instructional strategies. When comparing this study's results with those of Henderson and Dancy [1], it appears these college instructors share at least some characteristics of those studied in the national project. In addition to the familiarity and usage averages for each item, averages were calculated for each category, where "no encounters" was assigned a zero, "one encounter" a one, "multiple

TABLE 2. Teaching experience of respondents

	High School	College
Years teaching	Instructors	Instructors
0 – 2	9%	5%
2 – 5	14%	18%
5 – 10	16%	20%
10 – 20	32%	24%
More than 20	29%	33%

TABLE 3. Familiarity of college respondents with some of the instructional strategies listed on the survey

Strategy	At least one encounter	Multiple encounters	Comparison data from Henderson and Dancy ¹
Peer Instruction/ ConcepTests	80%	69%	64%
Interactive Lecture Demonstrations	69%	55%	45%
Physlets	66%	42%	56%
Just in Time Teaching	60%	36%	48%
Workshop Physics	58%	46%	48%
Tutorials in Introductory Physics	55%	42%	47%
Real Time Physics	47%	35%	32%
Ranking Tasks	47%	35%	39%
Modeling	46%	24%	33%
Investigative Science Learning Environ.	36%	18%	21%
Socratic Dialogue Inducing Labs	31%	16%	16%

encounters” a two and “able to lead encounters” a three.

To compute average usage for each item, as well as the categories, an instructor who said that they did not use an item was assigned a zero. If the instructor stated “partial adoption” (used parts of the item or an adaptation), they were assigned a one. Those who stated “complete adoption” were assigned a two.

In addition to reporting their usage of specific strategies, instructors were asked to give the percentage of class time that they spend on various activities. Activities such as instructor lecture, small group work, experiments, think-pair-share were provided as starting points, with “other” as an option to describe an activity that was not one of the nine provided ones. These responses were then used to estimate the fraction of class time where students were interacting with each other. To account for differing course structures, especially between college and high school, formal lab time was removed from the total. To emphasize instruction, rather than assessment, the fraction of time spent on tests and quizzes was also removed from the total.

High school instructors generally devoted a greater fraction of their courses to student-student interactions than college instructors, 0.33 versus 0.23 ($p < 0.01$). Among the high school instructors there were 42% who indicated less than 0.20 time spent on student-student interactions and 10% less than 0.10. More college instructors described classrooms that had little student-student interaction— 56% for less than 0.20 and 33% for less than 0.10.

Influence of Community

Instructors were asked how many AAPT (National and sectional) and other physics education related meetings they attend on average each year. Among the high school instructors, there was no correlation with their familiarity of research-based instructional strategies and conference attendance. College

instructors’ conference attendance did significantly correlate with their familiarity average for four of the six instructional strategy categories— whole course ($p < 0.001$), lecture ($p < 0.01$), recitation ($p < 0.01$), text ($p < 0.003$) and assessment ($p < 0.00003$). However, conference attendance did not correlate with usage among the high school and college instructors.

The frequency of reading journals showed nearly identical correlations as conference attendance. Instructors were asked how many times per year they read *American Journal of Physics*, *Journal of Research in Science Teaching*, *Journal of College Science Teaching*, *Physical Review Special Topics: PER*, *Physics Education* and *The Physics Teacher*. For high school teachers, the frequency only correlated with the familiarity of lecture ($p < 0.05$) and textbook strategies categories ($p < 0.02$) and the usage of assessment strategies category ($p < 0.02$). The college teachers had statistically significant correlations with the lecture ($p < 0.003$), lab ($p < 0.05$), recitation ($p < 0.001$), text ($p < 0.003$) and assessment ($p < 0.003$) familiarity categories, but only the lecture ($p < 0.05$) and assessment ($p < 0.01$) usage categories.

Much like the usage averages for the specific instructional strategies, the general classroom student-student interactivity percentage showed no correlation with conference attendance or journal reading for either high school or college instructors. Those who attend more conferences or read more journals are not more likely to employ specific research-based instructional strategies or have greater student-student interaction.

One item asked instructors to identify how they would complete the following “When I develop my lesson plans and activities...” The ends of the five-point continuum were “...I consult others or literature.” and “...I develop them on my own without consulting others or literature.” The RBIS familiarity, RBIS usage and student-student interactivity of respondents who identified with the two ends were compared. Among the high school instructors there

was no difference between the two groups. Among college instructors, there was a difference between the two groups' familiarity and usage of only assessment strategies ($p < 0.02$ and $p < 0.05$ respectively). The fraction of class time devoted to student-student interaction was different between the college, but not high school, teachers at the two ends of the continuum ($p < 0.05$).

In addition, other questions that focused on the respondent's interactions with their colleagues and supervisors did show differences for RBIS familiarity, RBIS usage and student-student interactivity among college instructors.

Those who agree (or strongly agree) with the statement "I often discuss ideas for different pedagogies with my peers." are more likely to be familiar with RBIS than those who disagree or are neutral with the statement ($p < 0.01$ for all strategy categories except lab). Those who agree also have statistically greater amounts of student-student interaction. ($p < 0.01$).

A second item that showed differences among college instructors was "I actively seek feedback about my teaching from my colleagues, administrators, and experts." Those who agreed with the statement were more likely to be familiar with lecture and assessment strategies and more likely to use lecture, recitation and assessment strategies. They also devoted a greater portion of their classes to student-student interaction ($p < 0.005$).

On average, high school and college teachers were very positive on these two questions. For the first item, only 8% of high school and 5% of college teachers disagreed (or strongly disagreed). For the second 17% of high school and 20% of college teachers disagreed (or strongly disagreed).

Intrinsic Interest

Among both populations, there appears to be considerable intrinsic interest in improving teaching. The following cluster of statements was on the survey:

- Understanding what is the best way to explain physics is important to me.
- I like to teach.
- I think that learning how students learn is interesting.
- I like learning the most effective ways to help students learn.

An average intrinsic score was computed by assigning agree and strongly agree answers a +1, disagree and strongly disagree answers a -1 and neutral a 0. All of the high school teachers had an

average score 0.75 or above, with 92% agreeing with all four statements. The college teachers were also positive, but with a slightly lower average. 11% had an average less than 0.75. For those in this small group, their average fraction of time devoted to student-student interaction was 0.093.

The high level of intrinsic interest may be related to how the survey was distributed. Subscribers who have joined the section listserv are likely to be more interested in teaching than those who do not join.

CONCLUSIONS

While both high school and college teachers reported attending an average of 0.64 and 0.84 physics education conferences per year respectively, there was no connection with their usage of research-based instructional strategies or amount of student-student interaction. Similarly, their journal reading (averages of 7.4 and 13.3 journals per year) did not correlate with RBIS usage or student-student interactivity. No matter how knowledgeable or involved in the teaching community a teacher is, it takes more to see differences in the classroom.

However, interactions between a teacher and their "local teaching community" do show some connection to classroom practices. Those who do not have positive relationships with their colleagues do not learn about, or use, RBIS and have much less interactive classrooms.

These observations would seem to indicate that greater adoption of RBIS would be accomplished by helping departments and schools change their cultures. Rather than trying to educate and persuade individual teachers, a systemic approach that includes the social interactions of colleagues would be beneficial.

On the individual scale, beliefs and values, such as intrinsic motivation, do correlate with a teacher's classroom practices. Again, simply educating teachers about the options and the logic and evidence supporting them, is not sufficient. Teachers' motivation needs to be addressed, without it no amount of information will change their classroom practices.

REFERENCES

1. C. Henderson and M. H. Dancy, *Phys. Rev. ST- PER.* **5**, 020107 (2009).
2. M. H. Dancy and C. Henderson, *AIP Conf. Proc.* **1179**, 121 (2009)
3. M. Neuschatz, M. McFarling, and S. White, *Reaching the Critical Mass*, College Park, MD: AIP 2008, p. 14.
4. <http://homepages.wmich.edu/~chenders/rbis.htm>
5. E. F. Redish, *Teaching Physics with the Physics Suite*, (John Wiley & Sons, Hoboken, NJ, 2003)