Variables that Correlate with Faculty Use of Research-Based Instructional Strategies

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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 (a 50.3% response rate). This paper examines how 20 predictor variables correlate with faculty knowledge about and use of research-based instructional strategies (RBIS). Profiles were developed for each of four faculty levels of knowledge about and use of RBIS. Logistic regression analysis was used to identify a subset of the variables that could predict group membership. Five significant predictor variables were identified. High levels of knowledge and use of RBIS were associated with the following characteristics: attendee of the physics and astronomy new faculty workshop, attendee of at least one talk or workshop related to teaching in the last two years, satisfaction with meeting instructional goals, regular reader of one or more journals related to teaching, and being female. High research productivity and large class sizes were not found to be barriers to use of at least some RBIS.

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INTRODUCTION

We have previously reported results from a national web survey to describe the overall picture of physics faculty knowledge about and use of research-based instructional strategies (RBIS) [1]. The survey asked faculty to rate their level of knowledge about and use of 24 specific RBIS (e.g., Peer Instruction, Workshop Physics, Physlets, etc.). We found that most faculty (87.1%) indicate familiarity with one or more RBIS and approximately half of faculty (48.1%) say that they currently use at least one RBIS [1]. In this paper we examine differences in faculty levels of knowledge about and use of RBIS by identifying correlations between knowledge/use and 20 potential explanatory variables. Knowledge of these correlations can help researchers to better understand reasons behind variations in faculty levels of knowledge/use of RBIS as well as to identify barriers to use.

In the first part of the paper we describe how we created four groups of faculty based on their knowledge about and use of RBIS. In the second part we introduce the 20 explanatory variables and identify which variables are correlated with faculty group membership. In the third part we present and discuss logistic regression models to identify five important explanatory variables and their relationship to group membership.

Four faculty groups

The first step in the analysis process was to identify a small number of faculty groupings based on their reported levels of knowledge and use of RBIS. In the web survey, for each of the 24 RBIS, faculty were asked to select one of the following choices: 1. I currently use all or part of it, 2. I have used all or part of it in the past, 3. I am familiar with it, but have never used it, 4. I've heard the name, but do not know much else about it, and 5. I have never heard of it. Respondents who answered '1' were categorized as users of the RBIS and respondents who answered '1', '2', or '3' were categorized as having knowledge of the RBIS.

Respondents were divided into six categories according to the number of RBIS that they knew about (none, low, high) and the number of RBIS that they reported using (none, low, high). The cutoff between low and high levels of use was determined so that the number of respondents in the low and high groups were approximately the same. Once the level of use cutoffs were determined, the level of knowledge

TABLE 1. Number of respondents in each category

<table>
<tr><th colspan="2"></th><th colspan="3">Level of Use</th></tr>
<tr><th colspan="2"></th><th>None
(0 RBIS)</th><th>Low
(1-3 RBIS)</th><th>High
(>3 RBIS)</th></tr>
<tr><td rowspan="3">Level of Knowledge</td><td>None
(0 RBIS)</td><td>Group A,
N=100
No knowledge or use</td><td></td><td></td></tr>
<tr><td>Low
(1-6 RBIS)</td><td rowspan="2">Group B,
N=277
Some knowledge, no use</td><td rowspan="2">Group C,
N=179
Some knowledge, some use</td><td></td></tr>
<tr><td>High
(>6 RBIS)</td><td>Group D,
N=159
High knowledge, high use</td></tr>
</table>

cutoffs were determined so that all users who were placed in the low level of use were also placed in the low level of knowledge. In order to assist in developing statistical models it was desirable to develop an even smaller number of groups. Based on an examination of the characteristics of each of the six groups it was decided that the non-users with low knowledge were quite similar (as measured by group averages of the explanatory variables) to the non-users with high knowledge. Thus, these two groups were combined. Similarly the low users with low knowledge were combined with the low users with high knowledge. Thus, we emerged with the four faculty groups (A, B, C, D) summarized in Table 1.

Explanatory variables

Twenty explanatory variables were developed from the survey responses. Table 2 defines the 20 explanatory variables and identifies which variables are significantly correlated with group membership. Relationships among explanatory variables and group membership variables were tested by a Pearson's chi-square test in the case of categorical explanatory variables, and by the one-way ANOVA in the case of continuous variables such as years of teaching experience. Results (p-values) are reported in Tables 2.

Faculty profiles

The correlations described above fail to capture the entire picture. Here we present descriptions of faculty characteristics within each of the four groups A, B, C, D based on comparing the trends discovered in the data to the hypothetical situation when explanatory variables are unrelated to the group membership variable. For space reasons, only selected variables (READ, SATF, RSH2, SIZE) are presented. A chi-square test followed by the residual analysis was done for categorical explanatory variables, and one-way analysis of variance test followed by the multiple comparisons was conducted in the case of continuous predictors. A significance level of 0.05 was used.

TABLE 2. Description of explanatory variables. Names of variables with $p<0.05$ are bolded.

Variable Name	Description
ATND (p = 0.000)	Attended talks/workshops related to teaching.
GEN (p = 0.000)	Gender.
NFW (p = 0.000)	Attended NFW. Attended physics and astronomy New Faculty Workshop.
RBIS (p = 0.000)	Interest in using more RBIS.
READ (p = 0.000)	Number of teaching-related journals read regularly.
INST (p = 0.000)	Type of institution. (two-year college, four year college BA, four year college grad.).
SATF (p = 0.001)	Satisfaction with meeting PER instructional goals of problem solving and conceptual understanding.
RSH2 (p = 0.002)	Number of research articles published in last two years.
JOB (p = 0.009)	Teaching as a main job responsibility.
PEER (p = 0.011)	Frequency of discussions with peers about teaching.
SIZE (p = 0.015)	Class size.
YEAR (p = 0.038)	Years of teaching experience.
PSTN (p = 0.065)	Type of position (full-time, permanent, full-time, temporary, part-time, permanent)
RANK (p = 0.200)	Rank. (lecturer, assistant professor, associate professor, full professor, other)
ENC (p = 0.242)	Level of departmental encouragement of efforts to improve instruction.
RSH3 (p = 0.348)	Currently have external funding for research (no, yes).
DGRE (p = 0.506)	Highest degree obtained. 1: undergraduate, 2: masters, 3: PhD
RSH1 (p = 0.721)	Number of research presentations made in last two years.
GOAL (p = 0.760)	Importance of instructional goals of problem solving and conceptual understanding.
CRSE (p = 0.874)	Course: algebra or calculus based.

Group A (no knowledge and no use)

a. More likely to not regularly read any journals related to teaching. (READ)
b. Less likely to be satisfied with meeting goals (SATF).

Group B (at least some knowledge but no use)

a. More likely to not regularly read any journals related to teaching. (READ)

Group C (at least some knowledge and some use)

a. More likely to have 4 or more articles published within the last two years. (RSH2)

TABLE 3. Comparison of odds ratios for the five predictor variables. Odds ratios are based on a new logistic regression model that contains all 13 significant explanatory variables. 95% confidence intervals for each odds, as determined from the nominal logistic regression analysis, are shown in parentheses.

Variable	Meaning	Odds(A) /Odds(D)	Odds(B) /Odds(D)	Odds(C) /Odds(D)	Odds(D) /Odds(D)
NFW	Odds = proportion of subjects who have attended NFW to proportion of subjects who have not attend NFW	0.06 (0.01, 0.49)	0.42 (0.23, 0.79)	1.11 (0.62, 1.97)	1.00
ATND	Odds = proportion of subjects who have attended one or more talks/workshop related to teaching in the last two years to proportion of subjects who have attended none.	0.10 (0.05, 0.21)	0.30 (0.16, 0.58)	0.27 (0.14, 0.54)	1.00
SATF	Odds = proportion of subjects who are satisfied or that they are meeting instructional goals to the proportion of subjects who are neutral or dissatisfied.	0.21 (0.09, 0.47)	0.55 (0.28, 1.10)	0.69 (0.33, 1.44)	1.00
READ	Odds = proportion of subjects who regularly read at least one teaching journal to subjects who regularly read none	0.23 (0.12, 0.44)	0.35 (0.22, 0.58)	0.42 (0.25, 0.71)	1.00
GEN	Odds = proportion of female subjects to male subjects	0.38 (0.16, 0.89)	0.34 (0.20, 0.59)	0.42 (0.24, 0.75)	1.00

Group D (high knowledge and high use)

a. More likely to teach classes with fewer than 36 (study median) students. (SIZE)
b. More likely to publish no articles within last 2 years. (RSH2)
c. More likely to regularly read at least one journal related to teaching. (READ)
d. More likely to be satisfied with meeting goals. (SATF)

Logistic Regression Model

Many of the explanatory variables are highly correlated with other variables. For example, gender is significantly correlated with group membership (Table 1). However, we also find that GEN is strongly related to many other variables in the study. So, the analyses presented so far cannot tell us what portion of the correlation between being female and using RBIS is due to being female versus being due, for example, to the increased likelihood that female faculty are younger (YEAR) and more likely to have jobs with more teaching responsibilities (JOB) than male faculty.

We used nominal logistic regression to identify a small subset of explanatory variables that can predict group membership. Logistic regression is a statistical procedure commonly applied when using categorical data to predict group membership. In developing the logistic regression model, we began with an initial set of explanatory variables that were significantly related to group membership in Table 2. As is common, a p-value of 0.1 was used as the cutting point for the initial set of variables. The model was fit by a backward elimination where variables from the initial set were eliminated one by one based on low levels of significance. It was possible to obtain several models because at many points in the variable elimination phase, there was more than one variable with similarly high p-values that could be eliminated. At these points the choice of which variable to eliminate was arbitrary. Because it was not possible to clearly develop a small set of significant predictor variables using all four categories of group membership we decided to use the two groups with the most extreme characteristics, group A and D, to determine the significant variables.

The process of developing the model with only two group categories (A and D) proceeded in the same way as the four-category model. In this case, though, it was always clear which variable should be eliminated at each step. After several rounds of elimination we arrived at a model with five explanatory variables: GEN, NFW, ATND, SATF, and READ - each highly significant as a predictor, with p-values around 0.01. The p-value of the Pearson's goodness of fit test for this model was 0.434 and the model resulted in 83.5% correct classification (64.6% for group A and 93.4 % for group D). The generalized coefficient of determination for this model, Nagelkerke's R^2, is 0.503. It represents the amount of variability that the model explains. All these measures indicate a strong model.

In order to develop a better understanding of the impact of these five predictor variables on group membership, we used logistic regression to control for the impact of the other variables. To do this we developed a new nominal logistic regression model that included all four faculty groups and retained all 13 of the significant variables ($p > .10$). We then compared odds ratios for each of the five predictor variables (see Table 3). Because it is difficult to interpret the effect of variables with more than two categories using odds ratios we dichotomized variables in the final model that had more than two categories, i.e., ATND and SATF.

Odds can be interpreted as ratios of percentages of study subjects with one level of a particular variable to study subjects with a different level of that variable. These odds, developed through the logistic regression process, allow us to assume that these subjects have equal levels of other variables in the model. For example, the proportion of female to male subjects in Group C is 0.42 of that for Group D. This means that ratio of females to males in Group C is less than half (0.42) of the ratio of females to males in Group D. Another way of saying this is that females are over twice as likely as males (1.00/0.44 = 2.38) to be in Group D vs. Group C. Similarly, females are nearly three times as likely as males (1.00/0.35 = 2.86) to be in Group D vs. Group B.

CONCLUSIONS AND DISCUSSION

The five variables identified in the final model and the odds ratios presented in Table 3 can be considered to be the most important factors in determining group membership. Each is discussed below.

New Faculty Workshop (NFW). NFW attendees were much more likely to be in the two groups of users (Group C and D) and were essentially nonexistent in Group A. The results suggest that all new faculty should be strongly encouraged to attend the NFW.

Attending talks and workshops related to teaching (ATND). As might be expected, faculty who have attended one or more of these talks/workshops have the highest odds of being in Group D. It is unclear, though, why the odds of being in Group C are similar to those of being in Group B. One might have expected the odds ratios to be higher for Group C. This may be an indication that faculty in Group C attended talks/workshops more than two years ago to learn about a RBIS and then have maintained this use while faculty in Group D continue to attend.

Satisfaction with meeting instructional goals (SATF). The instructional goals of developing student conceptual understanding and problem solving ability have been shown to be the two most common goals faculty have for introductory physics courses. In this study we find that faculty are more likely to be satisfied with meeting their instructional goals as their level of knowledge and use of RBIS increases.

Reading journals related to teaching (READ). It is not surprising that reading one or more of these journals is significantly related to use of RBIS.

Gender. This study found that female faculty are much more likely to be high users of RBIS than otherwise similar male colleagues. This result is consistent with the findings of others [2]. While a professor's gender may be difficult to change, the findings here suggest that institutions should consider hiring more female physics faculty. Currently (2006) only 13% of physics faculty are female and 43% of physics departments have no female faculty [3], so there is certainly room for improvement.

In addition to the five key variables discussed above, additional important variables can be identified from the faculty profiles. Here we focus on two correlations that were not found. We did not find that research productivity or class size was a barrier to at least moderate RBIS use.

Class Size (SIZE). Class size is often mentioned by faculty as a barrier to the use of RBIS. Here, we find mixed support for this idea. Class size was significantly related to group membership overall and the median class size reported by each of the faculty groups varies (A: 42, B: 35, C: 40, D: 32). However, the relationship between class size and group membership was only statistically significant for Group D, which had the lowest class size. Thus, class size does not appear to be a barrier to the use of at least some RBIS, although it may be a barrier to high levels of use.

Research Productivity (RSH1, RSH2, RSH3). Another characteristic that is often thought to distinguish between innovative and traditional teachers is the level of research productivity. It is often thought that faculty need to choose between focusing on research or focusing on teaching and that they cannot be highly productive in both. Other researchers, though, have found almost no relationship between research productivity and teaching effectiveness. Our results are most consistent with the latter. Only one of our three measures of research productivity (RSH2 = number of research publications in last two years) was significantly correlated with group membership. The correlation is interesting, though, in that high numbers of publications is associated with Group C while no publications is associated with Group D. Both of these groups are users of RBIS. Thus, similar to class size, high levels of use of RBIS may be inconsistent with high levels of research, but high levels of research do not seem to present a barrier to at least some RBIS use.

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