REGRESSION ANALYSIS EXPLORING TEACHER IMPACT ON STUDENT FCI POST SCORES

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High School Modeling Workshops are designed to improve high school physics teachers' understanding of physics and how to teach using the Modeling method. The basic assumption is that the teacher plays a critical role in their students' physics education. This study investigated teacher impacts on students' Force Concept Inventory scores, (FCI), with the hopes of identifying quantitative differences between teachers. This study examined student FCI scores from 18 teachers with at least a year of teaching high school physics. This data was then evaluated using a General Linear Model (GLM), which allowed for a regression equation to be fitted to the data. This regression equation was used to predict student post FCI scores, based on: teacher ID, student pre FCI score, gender, and representation. The results show 12 out of 18 teachers significantly impact their student post FCI scores. The GLM further revealed that of the 12 teachers only five have a positive impact on student post FCI scores. Given these differences among teachers it is our intention to extend our analysis to investigate pedagogical differences between them.

Keywords: High School, Modeling, Professional Development, Force Concept Inventory.

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INTRODUCTION

Physics teachers come from a variety of backgrounds and the shortage of science teachers often results in the teachers teaching multiple classes and subjects. As of 2002, physics teachers are more likely to teach multiple courses than are other high school science teachers; 1 in 10 physics teachers have only one course preparation compared to just over one-third of all other high school science teachers [1]. The additional preparation time is dependent on the schools' requirements and thus fluctuates from teacher to teacher. This means that some teachers will have more time to prepare for their course implementation.

Another difference among high school physics teachers is their education levels. In 2009, 30% of high school physics teachers had a Bachelors degree, 63% had a Masters degree, and 7% had a Doctoral degree (primarily not physics degrees) [2].

A teachers' depth of knowledge of their course content ultimately will affect how well they teach their students. Research has indicated that increased content knowledge positively influenced student achievement [3].

Professional development workshops, such as High School Modeling Workshops, play potentially significant roles in supporting physics teachers as these workshops are designed to help teachers develop an in-depth understanding of physics content and simultaneously develop pedagogical skill with the High School Modeling curriculum.

We acknowledge that there are many factors that may affect student learning. We set out to determine if teachers who had participated in a summer High School Modeling Workshop impacted their students' post Force Concept Inventory (FCI) scores while also investigating student attributes such as gender, representation status (if their ethnicity was represented in the field of physics), and pre FCI score.

HIGH SCHOOL MODELING WORKSHOP

Modeling Workshops [4] are roughly three weeks long and take place during the summer. They focus on advancing the pedagogical content knowledge and skill of physics teachers. The expectation is that by engaging teachers in constructing basic physical models will help them understand physics concepts in greater depth.

During the summer workshops high school teachers are given an introduction to the High School Modeling curriculum. The High School Modeling curriculum is a reformed teaching style developed at the Arizona State University. The workshops engage teachers in High School Modeling Instruction and allow them time to reflect on their own teaching practices along side other teachers.

Participants are supplied with a complete set of course materials, and work through activities alternately in the roles of student or teacher, as they practice techniques of guided inquiry and cooperative learning. Teachers receive stipends and/or tuition waivers, instructional materials, sometimes free housing, etc., at some workshops [4].

METHODS

To determine whether teachers who had participated in a High School Modeling Workshop played a significant role in students' post FCI scores, we collected FCI pre/post data from their physics classes totaling 1,344 students of 18 teachers. Data from each teacher ranged from 20-315 students. Teachers were selected based on two conditions: that they taught at least one year of physics at the high school level, and had attended at least one summer High School Modeling Workshop at Florida International University, (FIU).

Teachers who have completed the High School Modeling Workshop at FIU were provided paper copies of the FCI, Scantron response sheets and demographic surveys for students, and surveys for the teacher. Teachers also received pre-addressed, stamped envelopes to return the data to the PER group at FIU. The student demographic data collected includes: gender, ethnicity, and year in school. Teachers provided class type (honors/AP/regular), number of years of instruction after attending the FIU modeling workshop, as well as gender and ethnic background. It should be noted that all of the teachers taught at least one year prior to attending the Modeling Workshops.

The independent variables that were utilized for this study were pre FCI score, gender, representation status, and teacher ID. During this analysis all student FCI data were evaluated holistically; meaning the students data were tagged to a specific teacher, gender, and representation then evaluated for testing.

To be explicit, every teacher has a set of students, and each student has a gender, representation and FCI scores. When evaluating our information we do not want to treat the students as a cluster of scores but tie them into their teachers.

To achieve this the data were analyzed using a General Linear Model, (GLM) [5] via SPSS. For this study we will focus on creating a linear regression to explain how the independent factors contribute to the variance of the student post FCI score.

RESULTS

The results for the GLM analysis can be seen in Table 1. The independent variables, (left column), are the contributing factors to the students post scores that we considered in this study. The independent variables all correspond to a particular significance or Sig., (right column). The threshold p-value for significance in this analysis was .05, meaning that if an independent variable has significance above .05 it does not account for a significant amount of the variance in the post FCI score.

TABLE 1. GLM Regression Equation Inputs.

Independent Var.	Beta	Sig.
Pre	0.25	0*
Female	-0.005	0.82
U.Rep.	0.026	0.342
T1	0.124	0*
T2	0.111	0*
T3	0.015	0.535
T4	-0.056	0.033
T5	0.035	0.159
T6	-0.05	0.041
T7	0.21	0.433
T8	-0.062	0.023
T9	-0.059	0.017
T10	-0.386	0*
T11	0.053	0.032
T12	0.156	0*
T13	-0.051	0.04
T14	-0.035	0.152
T15	0.017	0.517
T16	-0.042	0.96
T17	0.142	0*
T18	-0.081	0.002

Table 1 Output of the GLM., (0* means that the value is less then .0001)

The effect size for the regression equation was found to be .366 by means of Cohen's f^2 [6]. As with all Cohen's f^2 if the value is larger then .35, the regression fits the data well.

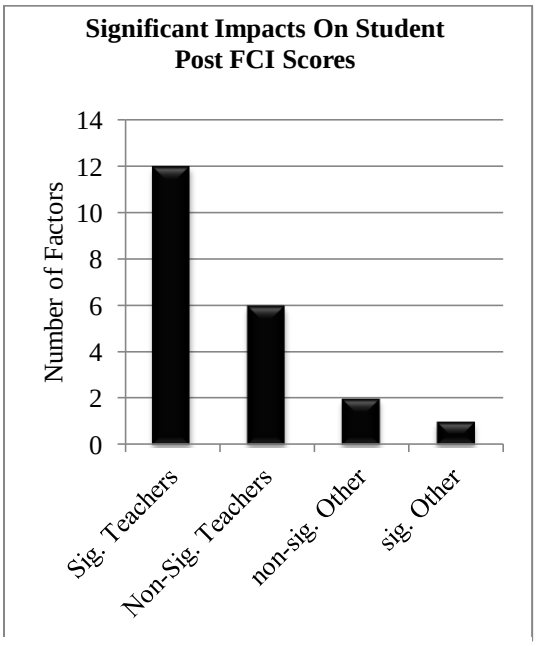

Figure 1. Shows the number of factors (gender, representation, teacher…) and how they contribute to the student post FCI scores.
The other categories are the representation, gender, and pre FCI score.

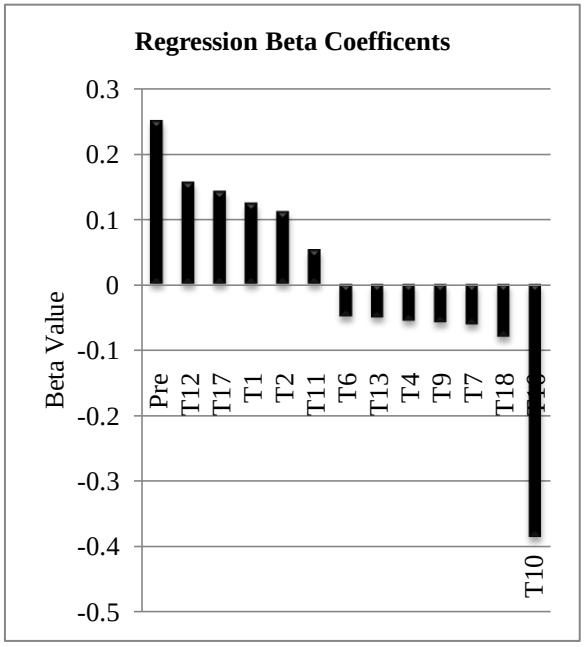

Figure 2. Shows the different beta values amongst significant teachers. The pre FCI score is also included as it is a significant factor.

ANALYSIS

The GLM allows us to investigate students' post FCI scores while co-varying the independent variables (student gender, representation status, and pre FCI score). The first model of the GLM contained pre FCI score, gender, and representation status and granted us an R^2 of .024 and an F value of 10.8. The second model contained the individual teachers as well as all of the fist model's variables. This yielded an R^2 of .245 and an F value of 36.8. With the increased R^2 and F values we can see that the addition of the teacher ID variables increased the models ability to account for the variance in the study.

For simplicity the GLM took all of the independent factors and established a Grand Mean for the student post FCI scores (the Grand Mean was found to be roughly 13 points). The GLM also states whether the independent factors accounted for a significant amount of the variance. If an independent factor is found to account for a significant amount of the variance this implies that this independent factor allows its corresponding pre FCI score to vary from that Grand Mean.

We can then use the regression equation to determine how each independent factor contributes to the post FCI score.

$$f(x) = \sum_{i=1}^{n} \beta_i x_i + e \quad (1)$$

Equation 1 looks into the weighted components of the GLM. The post FCI score, (f(x)), is described by the sum of all of the independent variables, (xi), and their weights (βi). The e in the equation represents the error or noise matrix.

For example in the case of the pre FCI score, every point the student has will be multiplied by a factor of .25 and then its contribution will be summed into the regression equation. All other independent variables are scaled in a slightly different manner. Whereas pre FCI scores can range from 0 to 30, all others correspond to a zero or one, this corresponds to a yes or no system. This means that each student post FCI score will correspond to only one teacher, gender, and representation.

DISCUSSION

We set out to determine if teachers who had participated in High School Modeling Workshops significantly impacted students' post FCI scores. Figure 1 indicates that 12 of 18 teachers of this study played a significant role in accounting for a portion

of the variance in their students post FCI scores. The variance in our study is the score distribution of students' post FCI scores. When a teacher accounts for a significant amount of the variance this means that their student population of post FCI scores indicates a clear deviation from the Grand Mean.

The pre FCI score accounted for a significant amount of the variance in student post FCI scores. A study by Henderson, (2002), found that the pre test score is strongly related to the post test results [7]. Thus our study agrees that student pre scores act as predictors for the post score as they account for a significant amount of variance.

There are also 6 teachers who did not significantly impact their students' post FCI scores. It must be noted that when a teacher is not found to account for significant variance in their students' post FCI scores this does not discredit their teaching ability. It means that they do not account for a significant amount of the variance within the regression equation. For the purposes of this study we have chosen to focus on the teachers that do account for a significant amount of variance to show a contrast in predictable scores.

In Figure 2 we take a more focused look at the 12 teachers and pre FCI score that significantly impacted student post FCI scores. This figure illustrates the different beta values amongst teachers and the pre score. The beta values can be seen as weights placed on their corresponding independent variable. As seen in Figure 2 these weights can be positive or negative and will affect student post score accordingly.

Figure 2 shows that the pre score has a positive impact on the student post score, as do 5 of the 12 significant teachers. The positive and negative beta weights amongst teacher indicate that some students will not see as dramatic post FCI scores as others..

The reasons for these differences are not clear; we can only speculate as to their probable causes. There are many factors that play into how students learn material within the classroom. Within this study we identify teachers who have participated in High School Modeling Workshops that significantly influence their students' post FCI scores. Establishing that these differences amongst teachers exist then leads us to the difficult task of establishing what key factors about them affect their students.

RESEARCH INTO DIFFERENCES AMONG TEACHERS

Having identified that differences among teachers who have participated in the High School Modeling Workshops exist, we suggest a research agenda that will allow us to better understand how the professional development workshops influence these differences.

First, we propose that studying the differences between teachers who have participated in High School Modeling Workshops and those who have not is in order, however, we currently have inadequate data in order to carefully study these differences that exist both at the student level as well as at the teacher level. In order to handle these multi-level differences we propose a Multilevel Linear Modeling study to better attribute these differences.

Second, we propose that the High School Modeling curriculum is unevenly enacted, thus a study of the implementation is needed to identify the role that the curriculum plays in the teacher effects.

Third, we propose a variety of other variables would strengthen the analysis of teacher differences. Among these variables are Reformed Teaching Observation Protocol [8] scores, which is related to the pedagogy the teacher employs, a measure of teachers content knowledge we posit would also be important. Finally, incorporating information about the schools, such as average socioeconomic status data would also indicate something of the context of the data.

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