Exploring the Effects of Professional Development on Science Teaching Practices

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Abstract

The science education reform movement emphasizes the importance of professional development as a means of improving student science achievement. Reformers have developed a vision for professional development based upon intensive and sustained training around concrete tasks that are focused on subject-matter knowledge, connected to specific standards for student performance, and embedded in a systemic inquiry context. Researchers used measures from the National Science Foundation Teacher Enhancement program as well as a 35 item Grade 4 science field test to examine the relationship between professional development, teaching practices and student performance. Researchers did not identify significant correlations between student gain scores and professional development contact hours, but we did find positive correlations between student gain scores and: (a) the number of science lessons taught per week ($p<.05$), (b) introducing content through formal presentation ($p<.01$), (c) real world context to teach science ($p<.05$), (d) assigning science homework ($p<.01$), (e) using non-textbook science related material ($p<.05$), (f) using computers for data analysis ($p>.05$), and (g) audiovisual presentations ($p<.05$).

Subject/Problem

Professional development is the foundation of nearly every educational effort to improve student achievement. In a 1985 national survey, teachers ranked in-service training as their *least effective* source of learning (Smylie, 1989). Guskey (1986) noted that nearly every major work on the topic of staff development down played its effectiveness. He attributed these historically dismal results to a poor understanding of teachers' motivations and a lack of insight into both the individual and environmental factors in the process of change.

Despite shortcomings, advances in science professional development hold promise as a way of influencing the teaching and learning of science in American public schools. Over the past decade, researchers and educators have forged a remarkable level of national consensus about what may constitute effective science professional development. Professional development is most likely to be of high quality if it immerses participants in inquiry, questioning, and experimentation and therefore model inquiry forms of teaching (Tinoca & Barufaldi, 2006). It must be both intensive and sustained (Meyer & Barufaldi, 2003). Professional development must engage teachers in concrete teaching tasks and be based on teachers' experiences with students (Darling-Hammond & McLaughlin, 1995) and must focus on subject-matter knowledge and deepen teachers' content skills (Cohen & Hill, 1998). Lastly, professional development must also be grounded in a common set of professional development standards and show teachers how to connect their work to specific standards for student performance (NRC, 1996; Hawley & Valli, 1999).

The logic of focusing on professional development as a means of improving student achievement is that high quality professional development will produce superior teaching in classrooms, which will, in turn, translate into higher levels of student achievement. Empirical evidence confirming this hypothesized chain of events in science is starting to emerge (Barufaldi, 2007). A handful of recent studies have investigated the relationship between professional development and teaching practice. In a study of teachers who participated in Ohio's Statewide Systemic Initiative in science and mathematics, Supovitz, Mayer, and Kahle (2000) found that highly intensive (160 h), inquiry-based professional development changed teachers' attitudes towards reform, their preparation to use reform-based practices, and their use of inquiry-based teaching practices. Further, they found that these changes persisted several years after teachers concluded their experience.

Few studies have documented a relationship between science teaching practices and student achievement in science. An evaluation of the Merck Institute of Science Education by the Consortium for Policy Research in Education (CPRE, 1999) examined the link between inquiry-based teaching practices and student achievement as measured by the Stanford 9 achievement test. The authors identified a statistical relationship between inquiry-based practice and fifth grade student achievement, but did not detect a similar association in the seventh grade. Ohio's Statewide Systemic Initiative also has statistically linked their intensive professional development to gains in student achievement (Kahle & Rogg, 1996).

Purpose

In this study, we investigate the relationship among high quality professional development and inquiry-based teaching practices and student performance. We also investigate the influence of student activities as reported by the teacher on this relationship.

More specifically, in this study we address the following research questions:

1. Is high quality professional development that utilizes standards-based curriculum and inquiry-based teaching practices statistically related to student performance?
2. If so, what levels of professional development are associated with greater use of student performance?
3. How do teacher background characteristics mediate the relationship between professional development and student performance?

The Sample

Data were obtained from teacher survey responses and performance data from students in five regional professional development collaboratives across Texas. The sample represented a unique view of science teaching and student performance. The localities ranged from large urban areas like San Antonio, Texas, to smaller towns like Abilene and Gainesville, Texas. TRC Project Directors recruited teachers that were both members and nonmembers of the TRC. After removing invalid responses (mostly due to either missing data that could not be reasonably imputed or consent was not given to use data in the analysis), we were left with surveys from 65 science teachers and 1,698 students in 54 schools. The sample thus resulted in a representative sample of teachers from the participating science professional development collaboratives that had participated in professional development to varying degrees. While some teachers had participated intensely in professional development, others had only slight involvement, and still others had no TRC professional development at all (see Table 1). Thus these data are a rare and unique representative sample of teachers with varying levels of formal exposure to high quality professional development.

Table 1. Number of Professional Development Contact Hours

	N (teachers)	Mean	Std. Deviation	Minimum	Maximum
Number of PD Contact Hours	65	29	51	0	256

Pre-Post Design

This study is based upon the data collected from teachers and students in Fall of 2006 and Spring 2007 as part the Grade 4 Science Field Test sponsored by the Texas Regional Collaboratives (TRC) for Science Teaching at the University of Texas at Austin. The teacher survey queried their teaching practices, student activities, and student use of technology as well as for demographic information. Teacher measures were modeled from the Local Systemic Change (LSC) through Teacher Enhancement program survey. Students took a 35 item science field test which measured four standards (Nature of Science, Life Science, Physical Sciences, and Earth Science.

A team of science content experts created items that were content valid for four different performance science standards at the 4th grade level. The science field test was piloted with 125 students and 40 items. The item analysis revealed five questions that were not discriminating and/or functioning properly, therefore, these items were removed. Performance standards did not have the same number of indicators (i.e., items). A performance standard was created by summing the respective items. A confirmatory factor analysis was conducted using the respective set of performance indicator variables. In summary, the Grade 4 Science Field Test is defining 44% of the factor variance (Sherron & Flecther, 2007). The validity coefficients (Standard 1 =.77, Standard 2 = .66, Standard 3 = .56, and Standard 4 =.64) are of respectable magnitude. Overall, test reliability is .77. The variance-covariance among the performance standards is reproducible by the confirmatory factor model. A gain score/change score (the post-test score minus the pretest score) was calculated and correlated with professional development membership, contact hours, and teacher practices.

Analyses

To investigate the relationship between professional development and the reform indicators of inquiry-based teaching practices and student performance, we used correlational analyses to evaluate the magnitude of the relationships between variables. That is, we looked for a statistical relation between two or more variables such that systematic changes in the value of one variable are accompanied by systematic changes in the other.

Results

Researchers did not identify significant correlations between the number of professional development hours and student achievement however, we did identify positive correlations between student gain scores and: (a) the number of science lessons taught per week ($p<.05$), (b) introducing content through formal presentation ($p<.01$), (c) real world context to teach science ($p<.05$), (d) assigning science homework ($p<.01$), (e) using non-textbook science related material ($p<.05$), (f) using computers for data analysis ($p>.05$), and (g) audiovisual presentations ($p<.05$).

Table 2. Correlations

	Difference	Contact Hours	Formal Presentation	Real World Context	Assign Homework	Use Non-Textbook	Use Computers	Audiovisual Presentation	Science Per week
Difference	1.000								
Contact Hours	-.005	1.000							
Formal Presentation	.097**	-.315**	1.000						
Real World Context	.055*	.246**	.352**	1.000					
Assign Homework	.068**	-.194**	.416**	.326**	1.000				
Use Non-Textbook	.051*	.134**	.246**	.445**	.292**	1.000			
Use Computers	.051*	-.060*	.175**	.111**	.506**	.167**	1.000		
Audiovisual Presentation	.058*	.027	.307**	.448**	.111**	.206**	.123**	1.000	
Science Per Week	.053*	.267**	.373**	.736**	.273**	.298**	.124**	.461**	1.000

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Discussion

Researchers were not able to provide evidence of a significant relationship between professional development hours, membership and student achievement. Researchers believe it is possible that our teachers are simply not getting enough training hours on a large scale to see effects in the short term. This supports the notion that training must be long term and sustained but it still does not tell us how much is needed before we see an impact on student performance. That is, the gestation period for the relationship between professional development and student achievement takes longer to manifest than what was measured. Is it reasonable to expect a correlation between professional development and student achievement in such a short amount of time? Curriculum may have been the silent partner of professional development in influencing teaching practices and student achievement. All the TRC projects have a heavy standards emphasis and are required to use approved curriculum materials in support of their initiatives. Even teachers with no professional development have access to these curriculum materials that encourage inquiry and investigative cultures. This might have affected their practices, raising the average, and resulting in an underestimation of the effects of professional development. Further research should try to explore the relative contributions of standards, curriculum, and professional development on teaching practices.

The results of this investigation did point towards a relationship between teaching practices and student achievement. This measure could be improved if the teacher data were longitudinal. Thus we cannot speak to the crucial question to whether professional development is linked to *changes* in practice. The ability to model change in practice would allow us to look at whether professional development was increasing teachers content preparations as well.

Does high quality professional development *change* practice? Furthermore, these analyses assume that the quality of all of the professional development provided by the TRC is equal. In other words, there is a lack of fidelity of the TRC model across the collaborative. How does the variation in implementation affect practice? And finally, these analyses do not capture variation in models, while some collaborative sites may make extensive use of study groups, yet others may utilize electronic support networks. Do different support strategies produce differential results? These questions suggest fertile ground for subsequent research.

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