The Impact of Whole-School Inquiry-Based Teacher Professional Development on STEM Achievement: A Case Study

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Abstract
Situated learning theories (Lave & Wenger, 1988) predict that students who work collaboratively in environments that are similar to the real world should experience deeper learning. To that end, the Connecticut Science Center has partnered with the Annie Fisher School in the Hartford Public School District over the course of the last four years to provide teacher professional development designed to support an inquiry-based learning approach. This study aims to measure the impact of this collaboration on student achievement. Observational longitudinal analysis of Connecticut Mastery Test science scores over a six-year period (two before and four after the PD partnership started) indicates a strong positive relationship. Results of a regression discontinuity analysis indicate that the change in school leadership and ensuing partnership had an initial marginally significant (p<.10) strong positive impact, with continued significant (p<.05) positive gains on the order of one standardized test performance category per year.

Goals and Objectives
The goal of this study is to determine the impact a whole-school inquiry-based teacher professional development program has had on student standardized test achievement at a school in Connecticut. In doing so, we will develop a better understanding of the impact of the partnership between an informal science education facility (the Connecticut Science Center) and a formal science education setting (the Annie Fisher STEM Academy) and formalize methodologies to assess the impact of such work on other schools.

Theoretical Framework
Studies show that professional development (PD) is a cornerstone of efforts to help teachers become better practitioners (Loucks-Horsley et al, 2003), a change that ultimately impacts student understanding (Hart et al., 2003; Johnson et al., 2007). These studies are embedded within the situated learning theoretical framework, which hypothesizes that authentic learning occurs in collaborative environments that mirror real-world scenarios (Lave & Wegner, 1988). Recognizing this important link, the Connecticut Science Center (CSC), in collaboration with the Hartford School District (HSD), has developed a comprehensive whole-school PD model to help boost inquiry-based teaching practice in area teachers. Initially implemented in one school, the Annie Fisher STEM Academy (AF STEM), this model has recently been replicated at multiple sites.

Since the summer of 2009, teachers from the Annie Fisher STEM Magnet School (AF STEM) in Hartford have received whole-school inquiry-based PD training from CSC. Under this PD model, all teachers in the school receive approximately 152 hours of PD over a three year period. Each year, all teachers attend a week-long summer institute on inquiry-based teaching as well as a two-day follow-up PD during the academic year. Between the first and second summer, teachers also attend PDs in support of Science Notebooking and Integrating Language Arts into Science. Teacher feedback has
been overwhelmingly positive, with statements such as “[W]e are generating more high level science students than previously,” and reports of increased confidence in implementing inquiry-based practices commonly appearing on follow-up surveys.

Prior research on the effect of systemic whole-school PD indicates that one measurable outcome of such efforts might be student standardized tests scores (Schneider et al., 2002; Johnson et al., 2010; Johnson et al., 2012). No research to date has applied a situated learning theoretical perspective to evaluate the effect of the CSCs PD on AF STEM student achievement. To do so, we propose the use of historical data on the state-wide standardized achievement test given in Connecticut. Until this year\(^1\), students in the state of Connecticut were required to take the Connecticut Mastery Test (CMT) every spring. This state-wide standardized test was broken down into sub-tests including mathematics and English language assessments (given every year between the 3\(^{rd}\) and 5\(^{th}\) grades) and science assessments (given in the 5\(^{th}\) and 8\(^{th}\) grades) (SDE, 2013). Based on their reported scale scores (range: 100-400), students were ranked into performance categories (below basic, basic, proficient, goal, and advanced) in each of the topics tested. Reports of student performance in various schools carried significant weight, impacting administration and teacher job security and non-educational factors such as local income tax rates.

The Research Question for this study was:

*What was the impact of a school-change program involving whole-school inquiry-based PD on 5\(^{th}\) grade student CMT scores at AF STEM?*

**Methodology**

Our preliminary analyses were a graphical examination of average school-level CMT scores from the years 2008-2013 (available on the CT Department of Education website). The first two years of this range, 2008 and 2009, represent a period before AF STEM began its collaboration with CSC. Visual inspection of trends over time will allow us to preliminarily determine if the implementation of whole-school inquiry-based PD is positively related to standardized test score gains in Science. To do so, we will compare the school’s trends to that of the Hartford School District, in which it is embedded, as well as the Connecticut State average scores over time.

Based on the findings of this preliminary exploration of the data, we then conducted a *regression discontinuity* analysis of 5\(^{th}\) grade CMT scores from 2008 to 2013 (roughly 180 students). To do so, we will fit the following population level model:

\[
CMT_i = \beta_0 + \delta CMC_i + \beta_1(YEAR_i - 2010) + \epsilon_i
\]

In this model:
- \(CMT_i\) is the model-estimated score on a given CMT science test
- \(CSC_i\) is a dichotomous dummy variable set to 1 if the test was taken in a year that AF STEM was collaborating with CSC and 0 if it was not
- \(YEAR_i\) is an ordinal variable that represents in which year (2008-2013) the CMT was taken

With the following estimated coefficients:
- \(\beta_0\) represents the model-estimated average CMT score in 2010 if PD had not been implemented
- \(\delta\) represents the impact of the CSC whole-school PD program on student CMT scores
- \(\beta_1\) represents the change in CMT scores each year (the CMT/YEAR slope)

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\(^1\) To align with the Common Core State Standards, CT will transition to the Smarter Balance computer-based test for math and ELA, while persisting with the 5\(^{th}\) and 8\(^{th}\) grade science CMT for the next few years.
The residual term, variance unexplained by the structural component of the model, is also represented.

**Results and Discussion**

The indirect effect of this teacher professional development can be seen on student performance on the 5th grade science sub-test of the Connecticut Mastery Test (CMT) (Figure 1). Science CMT scores at AF STEM were at or below district and state averages in 2008 and 2009 (the two years preceding their partnership with CSC). In the years since, average 5th grade science CMT scores have steadily risen, exceeding both district and state average scores in the process.

![Figure 1. AF STEM average science CMT scale scores 2008-2013](image)

As can be seen in Figure 1, the Hartford School District (HSD), in which AF STEM is embedded, routinely performs below the state average on the 5th grade science CMT. How might this whole-school PD model impact student performance in traditionally high-performing districts and schools? Since 2011, CSC has partnered with the Smith School in West Hartford CT. In contrast to HSD schools, schools in the West Hartford School District routinely perform at or above the state average across the various subjects tested on the CMT, including science. So far, the trends at the Smith School have been similar to AF STEM, with positive teacher feedback and average CMT scores recently surpassing the district average (Figure 2).

![Figure 2. Smith School average science CMT scale scores 2010-2013](image)

Following the lead of the model pioneered by the Hartford Public School District, other area schools have decided to incorporate this whole-school PD model as well. Winthrop Elementary School and Bennie Dover Jackson Middle School in New London CT have recently begun a partnership with CSC, identical to the model used at AF STEM and the Smith School. In addition, two newly opened schools, the Charles H. Barrows STEM Academy in Windham CT and Dr. Ramon E. Betances School...
in Hartford CT, have decided to integrate the PD and practices into their school cultures from the ground-up. Preliminary teacher feedback from the first round of PD has been positive, and we expect that student performance on the 5th (or 8th) grade science CMT in the coming years will be similar to the gains seen at AF STEM and the Smith School.

These observational findings clearly indicate a marked “jump” in scores between 2009 and 2010. To further quantify that trend, we conducted a regression discontinuity analysis, per the model above. We found that, between the years of 2009 and 2010, the school reform and partnership were responsible for a 35 point jump in scale score points (p<.10). This represents a gain in approximately two performance categories on the CMT. There was then a positive statistically significant (p<.01) gain in approximately 35 scale score points per year across the remaining years analyzed.

<table>
<thead>
<tr>
<th>Table 1. OLS regression model predicting student scale score controlling for school CSC collaboration, year, and the interaction of collaboration and year.</th>
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<tbody>
<tr>
<td>INTERCEPT</td>
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<tr>
<td>CSC</td>
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<tr>
<td>YEAR</td>
</tr>
<tr>
<td>CSCxYEAR</td>
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<tr>
<td>R²</td>
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<td>~p&lt;.10, **p&lt;.01, ***p&lt;.001</td>
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Figure 3. Regression discontinuity of 5th Grade CMT Science Scores at AF STEM 2008-2013

**Conclusion and Significance**

In conclusion, we detected a strong positive observational relationship between 5th grade CMT scores and teacher participation in the whole-school inquiry-based PD at the Annie Fisher Stem Academy, an urban magnet school in Hartford CT. This effect was also detected at a suburban elementary school in a nearby district that has adopted the same PD model. Follow-up regression analyses showed that the impact of the school reform was rapid and resulted in continued gains. This is the first study of its kind to evaluate the impact of this multi-year partnership, and the methodologies employed in the final paper can be used to evaluate the effect of the PD program on additional schools, as well as be employed by other STEM education researchers in the field.
References


