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The Effects of Professional Development Programs on Educational Outcomes in Mathematics and Sciences

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Table of Contents

Figures

Tables

Appendices

Executive Summary

Professional development programs are widely acknowledged for their success in determining outcomes in a variety of fields. These programs are particularly useful in education where new processes, methodologies, and curriculum need to be disseminated to vast numbers of administrators, educators, parents, and program analysts. Education is considered one of the top priorities for American policymakers, agencies, companies, and the general public. This fact has made educational outcomes progressively more important over time as larger expenditures are dedicated to providing positive educational effects. There has been a large body of research performed on what effects educational outcomes in the United States. Simultaneously, research has been performed on the outcomes of economic status, race, gender, and technological variance among schools on educational outcomes. However, little empirical research given all these variables has been performed, and even less research involving the effect of the National Science Foundation's Math and Science Partnership (a professional development program) on educational outcomes. This project is dedicated to an empirical analysis on the effect of this program in the Commonwealth of Kentucky. Its primary goal is to discern the effect, if any, of the Appalachian Math and Science Partnership (AMSP) on educational outcomes among its fifty one member districts.

Introduction

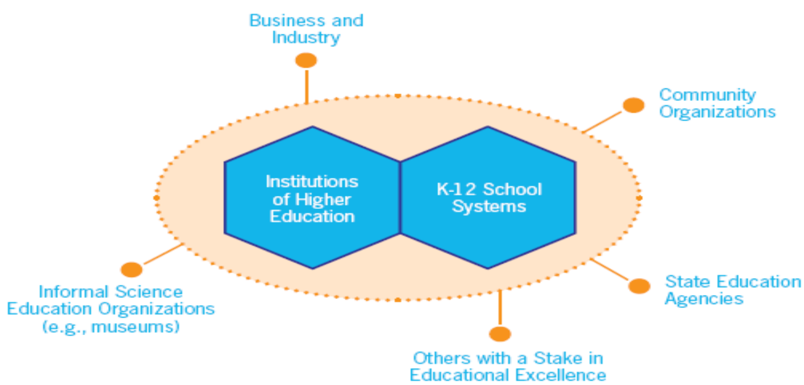
The United States is increasingly dedicated to improving educational outcomes in its public primary and secondary educational institutions. Costs of education have quickly risen over the last two decades, while performance indicators have slowly become more stagnant. This trend has changed the scope of the federal government on educational outcomes. A major initiative to include accountability has become the norm in educational standards. In 2001, the United States initiated the No Child Left Behind Act (NCLB). This legislation called for educational outcomes to be measured at the school level and simultaneously created accountability standards for those outcomes. At the same time, the government recommended an expansion of research or scientifically-based programs aimed at improving educational outcomes for all public institutions. Math and science achievement are considered integral to the success of the legislation which clearly states that "Math is a critical skill in the information age . . . math achievement is improving slightly, but much more work must be done to ensure that our children receive a sound background in mathematics. ***No Child Left Behind*** creates Math and Science Partnerships to rally every sector of society to help schools increase math and science excellence" (No Child Left Behind Act of 2001). With this mandate, the National Science Foundation created Math Science Partnerships (MSPs) for the purposes of increasing educational outputs in the mathematics and science arenas. Implementation of this program created multiple regional participating partnerships aimed at increasing outcomes in mathematics and sciences in a given region. It is thought that such programs increase interest and educational outcomes in these subject matters and that increased participation will lead to economic growth in a given area.

This theory culminated in President Bush's State of the Union Speech (2006), when the President announced the creation of the American Competitiveness Initiative (ACI). Though not yet passed by the United States Congress, ACI is considered an all inclusive program aimed squarely at keeping America's competitive edge in research and design capability as the global standard. ACI clearly draws comparisons between the nation's economic superiority and its technological advances. Furthermore, this initiative calls for significant federal investment. "Federal investment in R&D has proven critical to keeping America's economy strong by generating knowledge and tools needed to develop new technologies." ACI ensures "that America will lead the world in opportunity and innovation for decades to come." (See Appendix A) Education is considered integral to this endeavor.

A key portion of that funding will be provided to the "National Science Foundation, the Department of Energy's Office of Science, and the Department of Commerce's National Institute of Standards and Technology" by doubling their funding to its implementation over the next decade. The American Competitiveness Initiative states that "education is the gateway to opportunity and the foundation of a knowledge-based, innovation-driven economy" (State of the Union: American Competitiveness Initiative). In this manner, NCLB and ACI are clearly committed to improving math and science education across the nation.

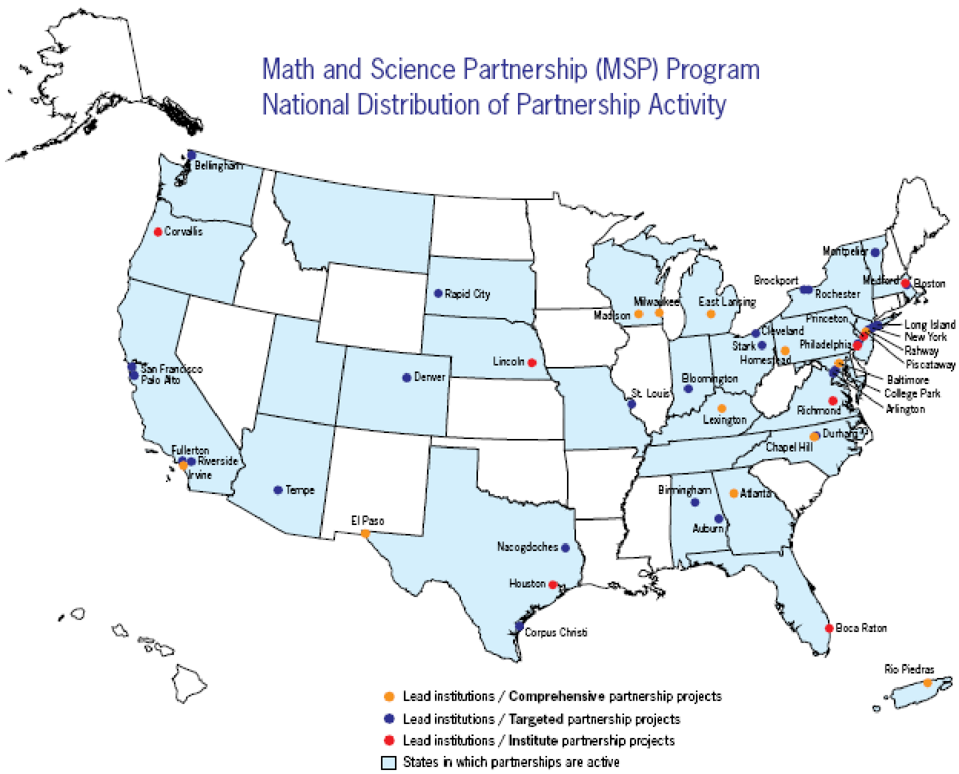
NCLB and ACI clearly call for new programs which will increase participation and educational outcomes in the mathematics and sciences. The Math and Science Partnership Program is dedicated to this goal by "strengthening America by advancing achievement in mathematics and science." The National Science Foundation awards grants to regional partnerships around the country in an effort to increase educational performance. These partnerships must be "composed of institutions of higher education, local K-12 school systems, and their supporting partners" (Math and Science Partnership Program, 3). Figure 1 shows the operating structure of a regional math and science partnership.

Figure 1



NSF states that "these partnerships develop and implement pioneering ways of advancing mathematics and science education for students. They bring innovation, inspiration, support, and resources to educators and students in local schools, colleges, and universities." (See Appendix B) NSF continues to create MSPs throughout the country by creating lead institutions to achieve its goals. "Funded partnerships bring together about 150 institutions of higher education with some 450 K-12 school districts and a host of other stakeholders." Figure 2 demonstrates current participating institutions in the MSP program (Math and Science Partnership Program, 12)

Figure 2



One key component of the Math Science Partnership Program is professional development. MSPs are dedicated to training teachers from member schools better methodology in the hopes that greater participation in the math and sciences among teachers and students leads to better educational outcomes. However, little research has been done on any of these professional development programs to ascertain whether the desired effect, or MSP goals, is being established or met. Are professional development programs achieving the outcomes that the government has essentially mandated?

Identification of the Issue

Math and science education is increasingly important as the global economy expands. The United States, it is argued, must be prepared to stay at the forefront of research and development to maintain its competitive advantage. Professional development programs such as the Math and Science Partnership Program were created in 2001-2002 to give educators in these subject areas the ability to increase participation in these fields and to improve the educational outcomes of students. There is little empirical evidence to suggest that professional development programs do in fact increase participation, not to mention show marked increases in educational outcomes.

The National Science Foundation currently receives $3.84 billion in federal funding on an annual basis, and funding for research and development is expected to top $110 billion in 2005 (National Science Foundation). It is critical to discern whether the outlays are achieving a desired effect. As the math and science partnership program is relatively new, it is difficult to expect that a dramatic effect will be seen at this point in educational outcomes in either mathematics or the sciences. This project will attempt to give a clear indication as to what effect the math and science partnership program has on educational outcomes, particularly in Appalachia.

<u>Literature Review</u>

The validity of educational professional development programs is grounded in many facets of effectiveness. Specifically, programs in the education arena intend to have an economic, educational, and testing outcome that is improving over time. Likewise, this particular professional development program is expected to have positive effects in mathematics and sciences. Each of these criteria is integral to the success of the Math and Science Partnership Program. The primary theory of the Math and Science Partnership Program is that higher quality teaching leads to better educational outcomes.

When the initial grant proposal was sent to the National Science Foundation, AMSP claimed that higher scores achieved in mathematics and sciences would lead to positive economic effects. Simultaneously, they argued that mathematics and science education lead to increased graduation rates. In addition, there is an accountability factor that exists. Accountability through testing has slowly become the standard in American education. The government increasingly looks towards outcomes, which it analyzes through testing, to judge the effectiveness of its public education system Finally, a supposition exists that professional development programs are capable of increasing educational outcomes by better preparing teachers for the complex educational mandates that are in effect today.

Eric Hanushek, a professor of education at Stanford University and member of the Board of Directors of the International Academy of Education, has completed considerable research on economic outcomes of school quality. He has carefully linked the quality of education and economic outputs. Dr. Hanushek argues that the effect of economic growth is due in large part to human labor, or "human capital." The effect of growth rates on GDP are, in large part, due to "knowledge and skills of the population." (Hanushek, 3-4) He also argues that this human capital is strongly linked to a given education system. More importantly, the externalities of human capital have an effect on other individuals in a given area. Hanushek points out that quality of a given labor force, as measured by mathematics and science test scores, was "extremely important. One standard deviation difference on test performance was related to one percent difference in annual growth rates of per capita GDP." Furthermore, he "found that immigrants who were schooled in countries that have higher scores on international math and science examinations earned more in the United States. When scores are standardized, they suggest that one standard deviation increase in mathematics performance at the end of high schools translates into 12 percent higher annual earnings." (Hanushek, 5-7) With respect to school quality, "class size, teacher experience, and teacher salaries [do not] positively influence student performance," but "a good teacher can move a typical student up at least four percentiles in the overall distribution." (Hanushek, 12, 15) This study clearly indicates that better teachers equate to better economic outcomes in a given region.

Considerable attention has also been given to the effect of mathematics and science education on graduation rates. A longitudinal study of the national high school class of 1992 points out that an individual who took calculus in high school had an 83.3% chance of earning a bachelor's degree. Conversely, those taking no more than pre-algebra had a mere 3.9% chance of earning a bachelor's degree. This is illustrated in Figure 3. (Adelman, 31)

Figure 3

Level of Math	Class of 1982: Percentage Reaching this level of math	Class of 1982: Earned Bachelors	Class of 1992: Percentage Reaching this level of math	Class of 1992: Earned Bachelors
Calculus	5.2 (0.36)	82.1 (2.45)	9.7 (0.54)	83.3 (2.72)
Precalculus	4.8 (0.37)	75.9 (2.43)	10.8 (0.65)	74.6 (2.04)
Trigonometry	9.3 (0.51)	64.7 (2.32)	12.1 (0.81)	60.0 (3.32)
Algebra 2	24.6 (0.75)	46.4 (1.54)	30.0 (1.08)	39.3 (2.31)
Geometry	16.3 (0.65)	31.0 (1.92)	14.2 (0.87)	16.7 (1.87)
Algebra 1	21.8 (0.69)	13.4 (1.33)	16.5 (0.92)	7.0 (1.24)
Pre-algebra	18.0 (0.66)	5.4 (1.19)	6.7 (0.53)	3.9 (1.34)

Notes: Standard errors are in parentheses. The columns for level of math may not add to 100.0 percent due to rounding.
Sources: National Center for Education Statistics: High School and Beyond/Sophomore Cohort (NCES 2000-194) and NELS: 88/2000 Postsecondary Transcript Files (NCES 2003-402 and Supplement).

The government is also attempting to judge effectiveness based increasingly on outcomes. As Eric Hanushek and Margaret Raymond argue, “test based accountability systems are now a central feature of U.S. Education Policy.” (Hanushek and Raymond, 1) In Kentucky, a system of assessment has been installed which uses norm-referenced assessments for grades 3, 6, and 9 and criterion-referenced assessments for grades 4, 7, 8, and 12. (Hanushek and Raymond, 9) If negative assessments are made at these public schools, data indicates that there are usually significant improvements made within a year of a negative assessment. (Hanushek and Raymond, 22) As there are many schools in Appalachia with below average student performance, schools are increasingly turning to new approaches to education in the hopes of higher student achievement.

Professional development programs are increasingly being sought out by educators in the hopes that such programs will increase student performance. “Even the casual reader of educational reform reports, legislative mandates, and contemporary educational literature would soon discover one common theme; professional development is critical to systemic educational reform and school improvement focused on enhancing learning outcomes for all children in public education." (Fullan and Hargreaves, 1996) Teachers are typically drawn to such events to gain new knowledge in educational methodology in their fields of expertise. It is clear that "teachers-as-learners are critical to pedagogical, social, political, and economic goals here in the US and other countries." Professional development programs serve the following three functions:

1. ***an establishment function. . . when the purpose is to promote organizational change through the implementation of programs, technologies, or procedures in schools and school districts;***
2. ***an enhancement function . . to improve teacher effectiveness;***
3. ***a maintenance function. . . to ensure compliance with administrative and organizational goals and objectives.*** (Bredeson and Scribner, 1-3)

Research indicates that PDPs have a positive effect on implementation of new methodology in a classroom. In a recent survey, 30% of those participating in a PDP planned on implementing changes in classrooms, while only 3% "said they would not." (Bredeson and Scribner, 7) Teachers are interested in three types of information that schools just do not seem to properly provide. These are "propositional, procedural, and . . . political knowledge. . . participants expect to learn the concepts, theories, and language." (Bredeson and Scribner, 9) As one author noted, "there is increasing recognition that school reform and staff development are integrally related." (Novick, 1) Professional development programs must help teachers prepare students for the next grade while encouraging a "constant interchange of thoughts and ideas." (Novick, 4)

School systems seem unequipped to undertake such a difficult task. National standards must be encouraged and met by these systems, however these nationwide standards are often not capable of meeting "the needs of children and families" in regional areas or communities. (Novick, 5)

MSPs are adept at bringing together various actors in a given community to properly assess what changes need to be made for substantial educational outcomes. Indeed, "learning will need to occur at multiple levels. Policymakers will have to learn, as well as children; teachers, as well as parents. Administrators, curriculum developers, school board members – everyone will have to learn. . . . effective staff development requires opportunities to be enriched by. . . 'the power of each other's ideas.'" (Novick, 6-7) The new rigors of teaching have paved the way for not just new means of assessment, nor just new means of accountability, it has also shaped the way we teach those who teach. It is in this way that "the professionalization movement was intended to make teacher education a state-of-the-art field by establishing an official and formal body of knowledge that distinguished professional educators from lay persons. . . part of the professionalization of teaching and teacher education was mounting recognition that training models were inadequate to the major tasks of teaching and school reform, and new models of professional development for prospective and experienced teachers were required." (Cochran-Smith, 7) Professionalization is increasingly important when teachers get educated at the collegiate level, but professional development programs are needed to continue this trend for individual teachers throughout their careers.

Institutional Background

Appalachia has a pejorative tradition in education and socioeconomic status. Creation of the Appalachian Math and Science Partnership (a $22.5 million grant awarded for five years) was based significantly on the highly visible disparity of income and poverty rates of Appalachia when compared to the national average. It is thought that higher level math and science participation in primary and secondary educational settings will lead to a gradual decline in the socioeconomic problems that are apparent in the region. Studies have continuously linked better educational outcomes in math and science with technological innovation and increased economic outputs.

This effort is led by the Appalachian Math Science Partnership (commissioned in 2002 as the largest single grant awarded in the University of Kentucky's history) designed to diminish educational disparities that exist in the subjects of math and science through utilization of the following strategic goals:

1. Improve the pre-service training of mathematics and science teachers
2. Improve preK-12 in-service mathematics and science teachers' knowledge of both content and pedagogy
3. Increase student opportunities and levels of achievement
4. Institutionalize mathematics and science program improvements
5. Advance the understanding of education reform in rural school environments
    a. Analysis of school/higher education partnership initiatives on mathematics and science education
    b. Research on key characteristics of students, schools, and projects affecting learning outcomes in mathematics and science

Research Design

This project assumes that Kentucky Core Content Test (KCCT) [math and science] scores are a function of enrollment in mathematics and science. For analysis, the project would like to ascertain whether the gap in mathematics and science scores between AMSP member schools has diminished over time when compared to all public institutions in Kentucky from 2001 through 2004.

The underlying assumption for this study is grounded in the theory that KCCT scores are a function of enrollment in mathematics and sciences. Based on this assumption and the data available, this report should be able to answer whether math and science scores in AMSP's footprint have changed when compared to all educational public institutions in the Commonwealth.

Units of analysis which are critical to the success of this research project include AMSP participating school districts on which data have already been collected. AMSP currently has fifty one member districts throughout Kentucky, Virginia, and Tennessee. Four years worth of valuable data on various demographic variables within AMSP schools have been collected. In addition, KCCT scores for all primary and secondary public institutions have been compiled. Virginia and Tennessee data are excluded due to the limited amount of observations from those states and the difficulty in comparing standardized test scores to those in Kentucky. For the purposes of this research, KCCT scores will be used to measure educational outcomes. Specifically, AMSP participating schools were compared to other schools across the state based on the KCCT scores along with various demographic factors (gender, race, free/reduced lunch participation, and SAIPE data) to measure the effect of professional development programs on math and science educational outcomes. Proficiency scores for all high schools in the state were accessed from the Appalachian Math and Science Partnership's database; the 2000-2001 school year will be the baseline with data being examined through the 2003-2004 school year.

Originally, the data collected for analysis came from surveys which were sent throughout member districts, properly filled out by administrators, and returned to AMSP for analysis. An Institutional Review Board (IRB) exemption form was approved for the use of such information for research purposes. Academic index scores at the school level that are used were collected and stored by Dr. Eugenia Toma of the Martin School of Public Policy and Administration at the University of Kentucky and provided by the state Department of Education. Mathematics and science proficiency and distinguished scores for all schools within the state were compiled by the author. It should be noted that participation in AMSP (included as a dummy variable) is based on registration data collected by AMSP.

Regression models will be the basis on which data are examined. Data was analyzed using Stata v.9 for econometric analysis. After isolating selection bias for these school districts, it will be determined whether increased or decreased participation in AMSP lead to higher or lower test scores. Simultaneously, teacher participation in AMSP was examined. After regressing for math and science scores, the research should be able to show whether teacher training/professional development programs have an effect on participation and educational outcomes. For the purposes of most of this analysis, fixed-effects regression models were chosen over ordinary least squares regression models, although an OLS model is used for the purpose of analysis. Ordinary least squares

(OLS) regression specifies some form of linear relationship between the dependent variable(s) (y) and a single independent variable (x). The equation for such a regression model is shown here as:

$$y = \alpha + \beta x + \varepsilon$$

Where α is the constant, β is the coefficient of the predictor, and ε is the error term. Fixed-effects regression models differ in scope by placing a binary variable in the model for each school. Fixed-effect regression assumes that there is systematic but unobservable variance at the school level. In this case, the error term is not random. . Fixed-effects models are shown here as:

$$\boldsymbol{Y_{it}} = \beta_0 + \beta_1 \boldsymbol{x_{it}} + \alpha_i + \varepsilon_{it}$$

Where α is the fixed effect for school ***i***, β_1 is the estimated coefficient of the independent variables, x_0 terms are all independent variables, β_0 is fixed, ε_{it} is a random variable with a probability distribution, and ***t*** is a time period (***t*** = 1 – 4).

<u>Analysis</u>

For the purposes of analysis, a fixed-effects regression model was composed with the independent variable ***mathpercen~u*** (Table 1) (variable descriptions are located in Appendix C). As is evident, the coefficient ***amspr*** is significant at the .01 level. This indicates that a school that participates in AMSP is likely to raise its proficiency in math by 2.45%. ***Time*** is also significant at the .01 level, as it is controlled in this fixed-effects regression. This model is highly significant in proving that AMSP is achieving exactly what it set out to do – raise math scores. This is not, however, the case when analyzing science proficiency scores.

Table 1: Fixed-Effects Regression for Math Percent Proficiency and Above

mathpercen~u	Coef.	t-statistic
constant	**.3008223 *****	8.06
	(.0373122)	
amspr	**0.0244974 *****	3.02
	(0.0081103)	
arsi	0.0783026	0.35
	(0.2232741)	
time	**0.0187758 *****	11.31
	(0.0016607)	
fr_per	-0.000126	-0.35
	(0.0003585)	
etb_p	0.0002684	0.5
	(0.0005347)	
eth_p	-0.001161	-0.78
	(0.0014944)	
eta_p	0.0009506	0.43
	(0.0022106)	
eto_p	-5.57E-05	-0.71
	(0.0000783)	
teacherto~04	0.0006547	0.94
	(0.0006988)	
observations	3974	
corr(u_i, xb)	-0.2668	

*** p≤.01
** p≤.05
* p≤.1

When regressing for ***sciencepercen~i,*** there is no significance of the professional development program (Table 2). AMSP is seen to have no statistically significant effect on science proficiency rates. Ratios of math and science teachers to total teachers in a school (***teacherto~04***) also have no effect on science proficiency scores. This would seem to indicate that AMSP is having some kind of unseen effect on math, whereas it has absolutely no statistically significant effect in the natural sciences. It is worth noting in this model that ***amspr*** and ***mathpercen~u*** are highly correlated (-0.2668) by their coefficients.

Table 2: Fixed-Effects Regression for Science Percent Proficiency and Above

scienceper~i	Coef.	t-statistic
constant	**.3521817 *****	8.84
	(.0398543)	
amspr	0.0128035	1.48
	(0.0086629)	
arsi	-0.0260639	-0.11
	(0.2384859)	
time	**0.0146881 *****	8.28
	(0.0017739)	
fr_per	0.0001162	0.3
	(0.0003829)	
etb_p	0.0000709	0.12
	(0.0005711)	
eth_p	-0.0007535	-0.47
	(0.0015962)	
eta_p	-0.0001568	-0.07
	(0.0023612)	
eto_p	-0.0000138	-0.17
	(0.0000837)	
teacherto~04	0.0003052	0.41
	(0.0007464)	
observations	3974	
corr(u_i, xb)	-0.0421	

*** $p \leq .01$
** $p \leq .05$
* $p \leq .1$

Due to this fact, it was postulated that the effect that AMSP had on math could be an indirect effect of the program, and not actually due to the work of AMSP throughout its member districts. When using the dependent variable ***rdai*** which is an academic index score for reading (Table 3), AMSP is seen to have a positive effect on reading scores as well. However, AMSP has absolutely no involvement with reading education. This information leads one to think that there is something significant about the schools with which AMSP has involvement, not necessarily about AMSP itself. Because of this fact, variables demonstrating averages and changes in academic index scores for all subjects were then created. Using these independent variables, ordinary least squares regression models were constructed using AMSP as the independent variable.

Table 3: Fixed-Effects Regression for Reading Academic Index Scores

rdai	Coef.	t-statistic
constant	**73.27321 *** (2.38873)**	30.67
amspr	**1.002974 * (0.5192241)**	1.93
arsi	1.323014 (14.29401)	0.09
time	**2.232339 *** (0.1063203)**	21
fr_per	**0.0002515 *** (0.0229483)**	0.01
etb_p	0.0182239 (0.0342283)	0.53
eth_p	**0.1904215 ** (0.095671)**	1.99
eta_p	**0.2807457 ** (0.141522)**	1.98
eto_p	-0.0038847 (0.0050159)	-0.77
teacherto~04	-0.0017279 (0.0447365)	-0.04
observations	3974	
corr(u_i, xb)	-0.0609	

*** $p \leq .01$
** $p \leq .05$
* $p \leq .1$

Using ***amspr*** as the dependent variable, it is clearly shown that the program does have some type of effect on math proficiency. This model uses a logistic regression model as ***amspr*** is a dummy variable. As is seen in Table 4, AMSP schools had naturally lower mathematics test scores (***avg_mathprof*** is the average math proficiency score for the 2000-2001 through 2001-2002 school years) when compared to the state as a whole. However, when inclusion into AMSP was achieved, their scores were already rising. This is explained by ***dif_***mathprof (1.907749). It is difficult on this basis, to explain that AMSP is having the direct effect on math proficiency scores that are explained by the first fixed-effects regression model.

Table 4: Logistic Regression for AMSP

amspr	Coef.	z-statistic
constant	-0.6708949	-0.65
	(1.028988)	
avg_mathprof	**-4.932792 *****	-3.84
	(1.283584)	
dif_mathprof	**1.907749 ****	2.17
	(0.8778062)	
avg_sciprof	1.530416	1.34
	(1.145807)	
dif_sciprof	-0.6570146	-0.83
	(0.7963304)	
avg_rdai	-0.0162002	-1
	(0.0162705)	
dif_rdai	-0.0033246	-0.28
	(0.0118087)	
avg_ssai	5.50E-06	0
	(0.0164292)	
dif_ssai	-0.0066328	-0.58
	(0.0113941)	
avg_idxai	0.0259222	0.7
	(0.0372508)	
dif_idxai *	0.143211	0.68
	(1.028988)	
observations	1041	
Pseudo R2	0.033	
Prob>chi2	0.0001	
Log likelihood	-545.86202	

*** p≤.01

** p≤.05

* p≤.1

† ***This was estimated as a logit model because the dependent variable is binary.***

To account for this, another ordinary least squares regression on math proficiency percentage was performed. When regressing for the independent variable ***mathpercen~u***, ***amspr*** is no longer significant.

Table 5: Ordinary Least Squares Regression for Math Percent Proficiency and Above

mathpercen~u	Coef.	t-statistic
constant	**.0667405 *****	4.95
	(.0134954)	
amspr	-0.0118311	-1.22
	(0.009718)	
arsi	**0.0200678 ***	1.68
	(0.0119186)	
avg_mathprof	**0.9374318 *****	41.14
	(0.022784)	
dif_mathprof	**0.1699491 *****	5.68
	(0.029938)	
fr_per	**0.0003491 ****	2.04
	(0.0001708)	
etb_p	**-0.0004655 ***	-1.95
	(0.0002392)	
eth_p	-0.000994	-0.64
	(0.0015596)	
eta_p	0.0020195	0.91
	(0.0022159)	
eto_p	-0.0000255	-0.42
	(0.0000613)	
observations	1040	
R2	0.6983	
Adj R2	0.6957	

*** p≤.01

** p≤.05

* p≤.1

However, it is worth noting that ***arsi*** is significant to the .10 confidence interval. ARSI was a preceding professional development to AMSP in Appalachia. ARSI is no longer in existence, but portions of the program are still utilized through the Partnership Institute for Math and Science Education Reform (PIMSER), a new program which "umbrellas" AMSP and ARSI. As was also expected, the average and difference in math proficiency scores were also significant. In addition, free and reduced lunch participation had a positive effect at the .05 confidence interval; whereas black ethnicity had an improving effect at the .10 level. The R-square is rather low here (0.0338), but not unexpected in an OLS regression model containing educational characteristics. This model indicates that AMSP has no significant effect on math proficiency percentages. Note: Lagged variables on the effect of AMSP for math and science proficiency were created to give a baseline estimate of the possible effect of the professional development program on math and science proficiency scores. These fixed-effects regression models are included in Appendices D and E.

Conclusion

The data initially suggests that AMSP has a positive effect on math proficiency percentages and reading academic index scores. However, it is not clear as to whether AMSP has a causality effect on math proficiency scores or whether it is simply an indicator of schools that were already improving. This does not discount the positive effect that AMSP has on its member schools and districts. Simply put, a school's participation in AMSP may indicate that it is an institution that is dedicated to improving its academic standing. This in itself is an important conclusion. AMSP may indicate which schools are likely to improve in the future.

Simultaneously, AMSP has only been in existence for two full school years for which the data were available. There is a possibility that AMSP has not yet fully integrated its programs to the extent that its causal effect would be seen. It is worth noting that this study should be longitudinal in nature and future research conducted on its effect.

Whether AMSP is causal or just an indicator, the schools in which it participates are improving, and improving in ways that were not hypothesized prior to this research. The fact that reading scores are improving was not expected. However, if AMSP is an indicator of a school's dedication to improvement, then it would be expected that all academic subjects would steadily improve. While AMSP was not shown to have a positive effect on science, it should be noted that science improvement is more difficult to achieve than in its math counterpart. Math skills, by and large, can be improved with nothing more than a pencil and paper, while science requires a hands-on approach. Funding throughout Appalachia is diminished when compared to its statewide cohorts due to economic problems that exist throughout the region.

Long-term dedication to AMSP should provide positive educational outcomes for participating members in the future. The fact that improved math and reading scores already exist is a testament to its effect.

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Appendix A

- ***Doubling the Federal commitment to the most critical basic research programs in the physical sciences over the next 10 years;***
- ***Encouraging the expansion of a favorable environment for additional private-sector investment in innovation;***
- ***Improving the quality of education to provide American children with a strong foundation in math and science;***
- ***Supporting universities that provide world-class education and research opportunities;***
- ***Providing job training that affords more workers and manufacturers the opportunity to improve their skills and better compete in the 21st century;***
- ***Attracting and retaining the best and brightest to enhance entrepreneurship, competitiveness, and job creation in America by supporting comprehensive immigration reform; and***
- ***Fostering a business environment that encourages entrepreneurship and protects intellectual property.***

Appendix B

- ***Enhance schools' capacity to provide challenging curricula for all students and encourage more students to succeed in advanced courses in mathematics and the sciences;***
- ***Increase the number, quality and diversity of mathematics and science teachers, especially in underserved areas;***
- ***Engage and support scientists, mathematicians, and engineers at local universities and local industries to work with K-12 educators and students;***
- ***Contribute to a greater understanding of how students effectively learn mathematics and science and how teacher preparation and professional development can be improved; and***
- ***Promote institutional and organizational change in education systems — from kindergarten through graduate school — to sustain partnerships' promising practices and policies***. (Math and Science Partnership Program, 5)

Appendix C

Variable Definition and Descriptive Statistics

Variable	Label	Obs.	Mean	Std. Dev.	Min.	Max.
amspr	Binary variable indicating participation in the Appalachian Math and Science Partnership	4659	0.1194462	0.3242649	0	1
arsi	Binary variable indicating participation in the Appalachian Rural Systemic Initiative	4659	0.1469199	0.3538366	0	1
avg_idxai	Average academic index score for a each school for the 00-01 and 01-02 school yr.	1041	67.82668	10.30237	34	107.6
avg_mathprof	Average math proficiency score for a each school for the 00-01 and 01-02 school yr.	1127	0.3250838	0.1412018	0.003268	0.8961416
avg_rdai	Average reading academic index score for each school for the 00-01 and 01-02 school yr.	1041	77.52097	12.50116	36.2876	112.7638
avg_sciprof	Average science proficiency score for a each school for the 00-01 and 01-02 school yr.	1135	0.3718161	0.1540551	0.02	0.9166666
avg_ssai	Average social studies academic index score for each school for the 00-01 and 01-02 school yr.	1041	67.81803	13.13173	33.0007	118.622
dif_idxai	Difference in academic index score for each school between the 00-01 and 01-02 school yr.	1136	-10.00449	25.69375	-100.85	67.3
dif_mathprof	Difference in math proficiency score for each school between the 00-01 and 01-02 school yr.	1136	0.0132528	0.0923029	-0.3333333	0.5378788
dif_rdai	Difference in reading academic index score for each school between the 00-01 and 01-02 school yr.	1136	-11.95571	32.44549	-112.7638	69.8336
dif_sciprof	Difference in science proficiency score for each school between the 00-01 and 01-02 school yr.	1136	0.0159666	0.1000772	-0.5515152	0.4958333
dif_ssai	Difference in social studies academic index score for each school between the 00-01 and 01-02 school yr.	1136	-7.804423	29.08055	-105.214	73.6184
eta_p	Asian ethnicity	3976	0.5837249	1.28745	0	27
etb_p	Black/African-American ethnicity	3976	9.376307	14.51429	0	100
eth_p	Hispanic ethnicity	3976	1.010264	1.868985	0	38.5
eto_p	Other ethnicity (excluding Caucasian ethnicity	3975	1.574598	22.63325	0	1422
fr_per	Free and reduced lunch percentage for each school	3975	49.17957	20.71399	0	100
idxai	Academic index score for each school	3976	71.18068	11.53027	34	114.6
mathpercen~u	Percentage of mathematics scores for a given school rated proficiency or distinguished	4618	0.3539114	0.1560257	0	0.9375
mathprof1	Lagged variable for math proficiency	3440	0.3465951	0.1549028	0	0.9375
rdai	Reading academic index score for each school	3976	79.72461	12.86447	28.62	130.588
scienceper~i	Percentage of science scores for a given school rated proficiency or distinguished	4652	0.3923643	0.1672596	0	1
sciprof1	Lagged variable for science proficiency	3464	0.3862655	0.1653306	0	1
teacherto~04	Ratio of math and science teachers to total number of teachers in a given school	4660	0.6412017	3.501696	0	38
time	Variable which indicates the year (e.g. 2000-2001 = Year 1, 2001-2002 = Year 2, etc.)	4659	2.519854	1.117498	1	4

Appendix D

Fixed-Effects Regression for Math Percent Proficiency and Above

mathpercen~u	Coef.	t-statistic
constant	**0.3525269 *****	7.15
	(0.0493374)	
amspr	0.0541972	5.08
	(0.0106674)	
arsi	0.1188362	0.47
	(0.2542605)	
fr_per	**0.0014792 *****	2.62
	(0.0005654)	
etb_p	-0.0000283	-0.02
	(0.0012848)	
eth_p	-0.0010814	-0.42
	(0.0025764)	
eta_p	0.006347	1.51
	(0.0042041)	
eto_p	-0.0000419	-0.47
	(0.0000895)	
teacherto~04	0.0012577	1.29
	(0.0009721)	
mathprof1	**-0.2406438 *****	-7.84
	(0.0306921)	
observations	2898	
corr(u_i, xb)	-0.8176	

*** $p \leq .01$
** $p \leq .05$
* $p \leq .1$

Appendix E

Fixed-Effects Regression for Science Percent Proficiency and Above

scienceper~i	Coef.	t-statistic
constant	**0.4209047 *** **	8.03
	(0.0524034)	
amspr	0.0396746	3.58
	(0.0110728)	
arsi	0.0057001	0.02
	(0.2673514)	
fr_per	**0.0010071 ***	1.70
	(0.0005929)	
etb_p	0.000638	0.47
	(0.0013507)	
eth_p	0.0003904	0.14
	(0.0027138)	
eta_p	0.0059797	1.35
	(0.0044153)	
eto_p	0.0000365	0.39
	(0.0000941)	
teacherto~04	-0.0002882	-0.28
	(0.0010211)	
sciprof1	**-0.2177795 *** **	-6.79
	(0.0320866)	
observations	2898	
corr(u_i, xb)	-0.8450	

*** p≤.01

** p≤.05

* p≤.1