A Review of The Teachers Academy for Mathematics and Science 13 Year Experience Implementing Inquiry Based Learning in Illinois Public Schools

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Chicago, IL
June 3, 2004

Section I Introduction and Background

1.1) Introduction

Since 1991 Teachers Academy for Mathematics and Science ("TAMS" or the "Academy") has been providing training in inquiry-based learning to schoolteachers of mathematics and science. TAMS serves exclusively teachers of students in grades pre-kindergarten through 8. Located in Chicago, Illinois the Academy has limited its professional development services to low-income public schools in the State of Illinois. The teaching and learning environments for TAMS schools are challenging. The term "low-income school" means that at least 75% of the students in the school are eligible for the free or reduced lunch program funded by the U.S. government.

Low-income schools have difficulty attracting and keeping strong teachers. School leaders such as principals in these schools are often overwhelmed with discipline and environmental issues. Another severe problem is that parents of children in low-income schools have difficulty with providing necessary learning support. In spite of these conditions, the evidence indicates that inquiry-based learning has a positive effect in improving math and science abilities.

Much of this paper presents the results of quantitative data that shows the effects of TAMS training on schools, teachers and students. The Academy has invested much time and money in developing assessments and in gathering and analyzing data. You will see that there are issues with both the data and the analytics. The statistical work uses a number of techniques. Each technique has its limitations. However, collectively the body of analytical work points to a clear conclusion. Students of teachers practicing inquiry-based methods show significant improvement on Illinois state tests.

Consistent observations of the Academy's trainers, professional developers (PD's), over the years are also presented. The Academy has a multitude of testimonials from teachers, principals and administrators to the positive impact of TAMS training on their classrooms. These evidence the change in attitude and motivation of both the teacher and her class. This attitude change has become a standard outcome of the TAMS program.

Over the course of 13 years the Academy has worked with approximately 5,000 teachers in approximately 200 public schools in Illinois. The evidence indicates meaningful improvement in math and science state test scores for many students. Enthusiastic engagement of teacher and student in the study of science and math is also demonstrated. Depending on the average class size and the average tenure for each TAMS trained teacher, many future students may benefit.

1.2) Background

TAMS is a private, non-profit organization serving Illinois schools. Through an intensive professional development program, the Academy seeks to train elementary school teachers in the teaching of mathematics and science. The Academy program works in partnership with elementary school teachers, principals, parents, and other leaders in the local school community to implement a "whole school" intervention program. The core of the program consists of a two-year long, comprehensive, standards-based professional development program in mathematics and science for public elementary school teachers. Teachers from participating schools complete a series of courses totaling 120 hours specifically targeted to the teaching of mathematics and science to elementary school students. In addition to providing professional development courses, Academy personnel attend 15 actual classroom sessions of each individual teacher participating in the program. During these classroom visits, program personnel observe how teachers implement the lessons taught in Academy courses and how the teachers incorporate Academy material into their daily lessons. This helps teachers in transferring their increased knowledge about content and pedagogy into practice in their own classrooms. And finally, the Academy distributes appropriate classroom teaching materials and student manipulatives including extensive technology resources to each teacher and school.

Since its inception TAMS has stressed the importance of empirically quantifying the program's *effects.* It has done this using primarily quantitative research processes. Prior to beginning the program teachers are asked to complete a background questionnaire, an attitude survey and skill tests in covering topics and content knowledge in mathematics and science. At the end of the first program year and again at the conclusion of the second program year teachers are asked to complete the attitude survey and skills tests. The information collected is used in assessing the program's impact on teacher attitudes and content knowledge. In addition, the Academy has collected both school-level and student-level test score information for each year from 1993 through 2003. This information includes data on the Iowa Test of Basic Skills (taken annually by students in Chicago District #299), as well as the Illinois Goal Achievement Program (IGAP), and the Illinois Student Achievement Test (ISAT). These quantitative data are supplemented by qualitative observations of the Academy's professional developers (PDs), who maintain running logs of their experiences with each teacher in an electronic database the Academy developed for this purpose. The Academy has been pioneering in its use of the test score data. TAMS was the first organization in Illinois to undertake the construction of a longitudinal database of same student test score performance over time.

Over the past 13 years, TAMS has established an impressive record of success in improving the teaching and learning of mathematics and science in the Chicago Public Schools (CPS) and other Illinois school districts. It has done this under the guidance and governance of a distinguished group of leaders in the science, education, and business communities. Through their efforts, TAMS has secured and invested over $73M in public and private funds to conceptualize, implement, and evaluate a strategy to improve mathematics and science instruction in the most distressed elementary schools.

The Teachers Academy for Mathematics and Science offers an intensive professional staff development program with extended follow-up and support. The program focuses on the best practices in mathematics and science education, emphasizing hands-on, inquiry-based instruction. The Academy teachers receive tools (manipulatives) they can use in their classrooms. Working together with the principal, teachers, and parents, the Academy supports the entire school community with a focus on:

The mathematics in the program is based on the *Principles and Standards for School Mathematics* developed by the National Council of Teachers of Mathematics, and the Illinois Learning Standards. These include number and operations, geometry, measurement, data analysis and probability, and algebra. During the program, teachers further develop their own knowledge and understanding of mathematics and practice using this knowledge with a range of different teaching techniques and materials. The Academy's professional developers emphasize the value of mathematics so teachers become confident and effective communicators of mathematics.

The science in the program is aligned with national and state standards and stresses science as inquiry. Physical science topics include properties and changes in matter, position, forces and motion, transfer of energy, and electricity and magnetism. Staff developers help teachers apply these to their science curricula. Teachers experience the process of scientific investigation through hands-on, inquiry-driven experiments. Further, teachers acquire methods for effectively integrating science with other disciplines.

Section II The TAMS Environment

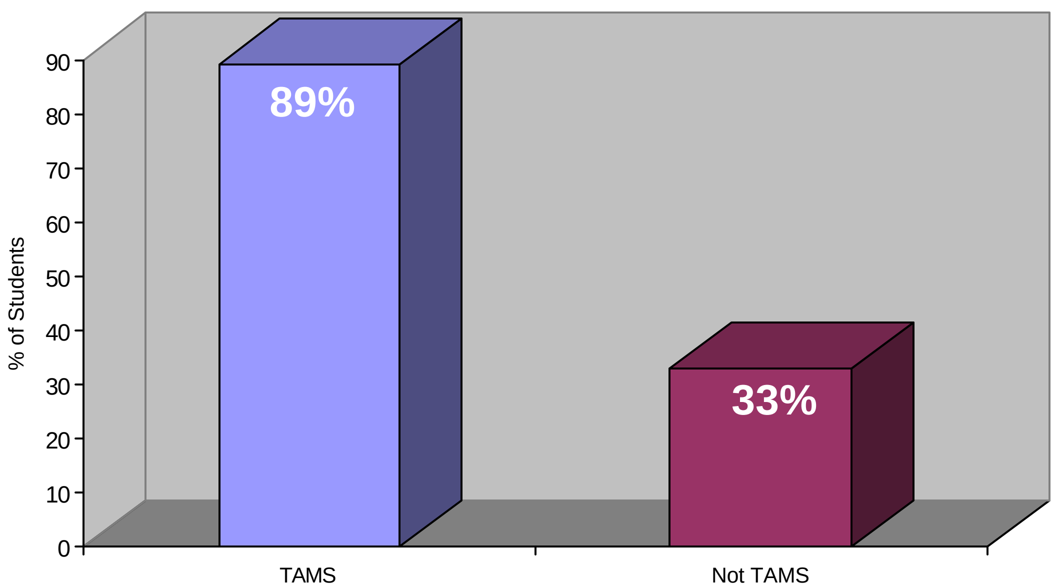
The state of Illinois serves approximately 2 million public school students, grades K to 12, in more than 4,000 schools.

Schools participating in the Academy program are among the most challenged schools in Illinois. Academy schools are specifically selected because they have historically poor performance on State standardized tests and serve schools with high proportions of minority and low-income students. Consequently, TAMS schools have significantly higher percentages of both minority and low-income students than non-TAMS schools.

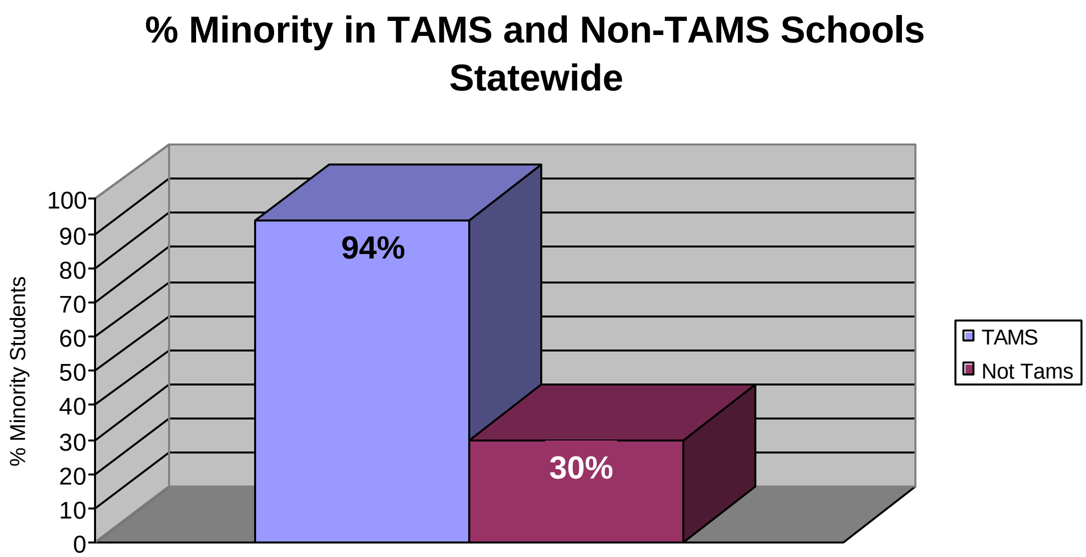
2.1) Statewide Comparisons

Students from low-income families (students eligible for luncheon assistance through the federal free and reduced lunch program) account for almost 90% of the students in TAMS schools. This compares to only 33% of students in non-TAMS schools statewide.

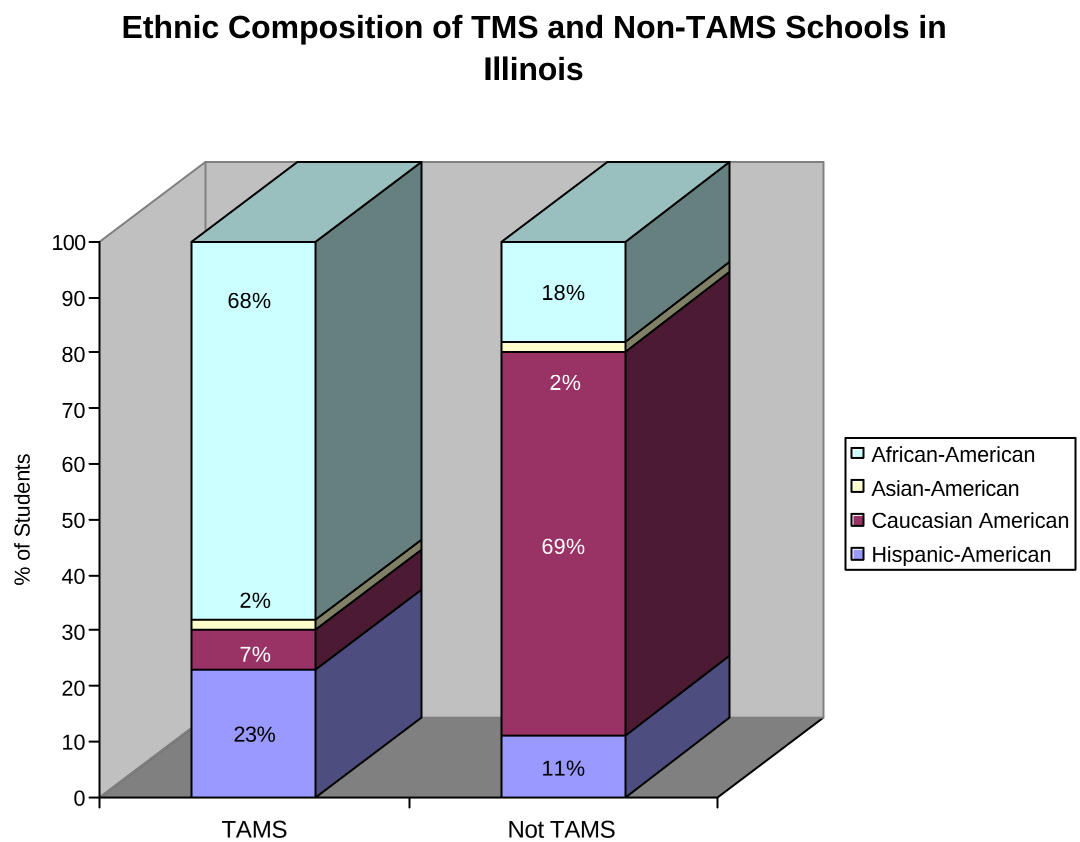
Percentage of Low-Income Students in Academy and non-Academy Schools in Illinois



- 94% of students in TAMS schools are from minority populations as compared to 30% in other Illinois public elementary and middle schools.



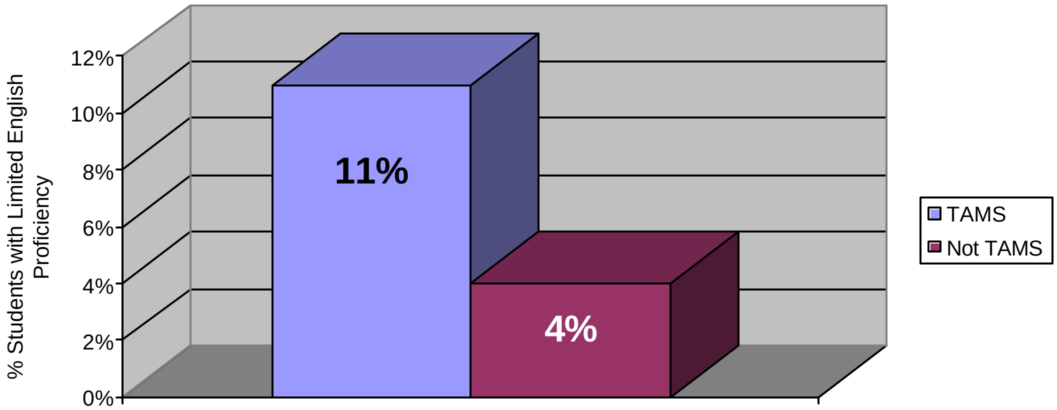
As the chart below indicates Caucasian Americans account for only about 7% of all students in Academy schools. This compares to almost 70% of students in non-Academy schools. By contrast, more than two-thirds of the student body in Academy schools is African-American as compared to less than 20% in non-Academy schools statewide, and 23% of the students are Hispanic Americans as compared to 11% in non-Academy schools statewide.



Schools served by TAMS also have higher proportions of students with limited English proficiency, higher truancy rates, and higher mobility rates than other public elementary and middle schools in Illinois. On average:

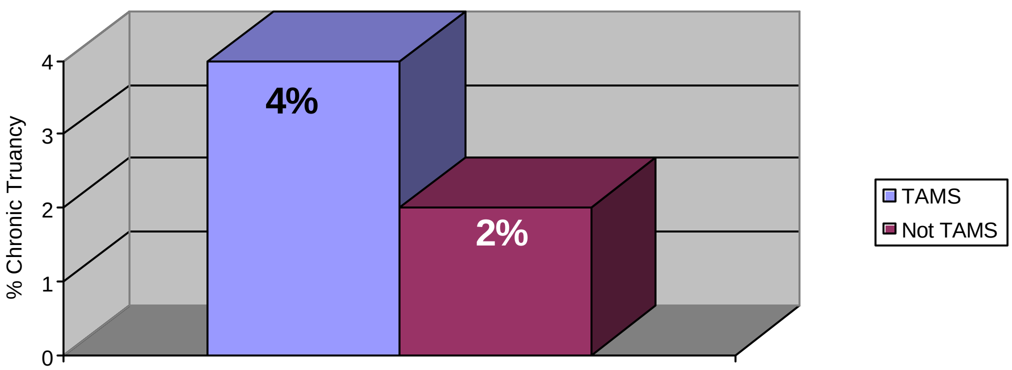
- 11% of students in TAMS schools have limited English Proficiency as compared to about 4% in other Illinois public elementary and secondary schools.

% of Students with Limited English Proficiency in TAMS and Non-TAMS Schools Statewide



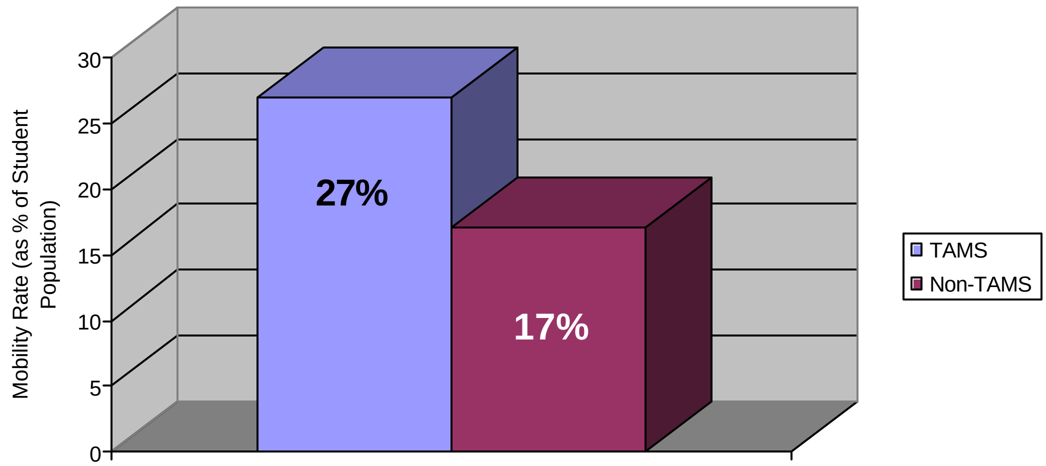
- The truancy rate in TAMS schools is 4% as compared to 2% in other Illinois schools.

% Chronic Truancy in TAMS AND Non-TAMS Schools Statewide



- The mobility rate in TAMS schools is 27% as compared to 17% in other Illinois public elementary and middle schools.

Mobility Rates in TAMS and Non-TAMS Schools Statewide



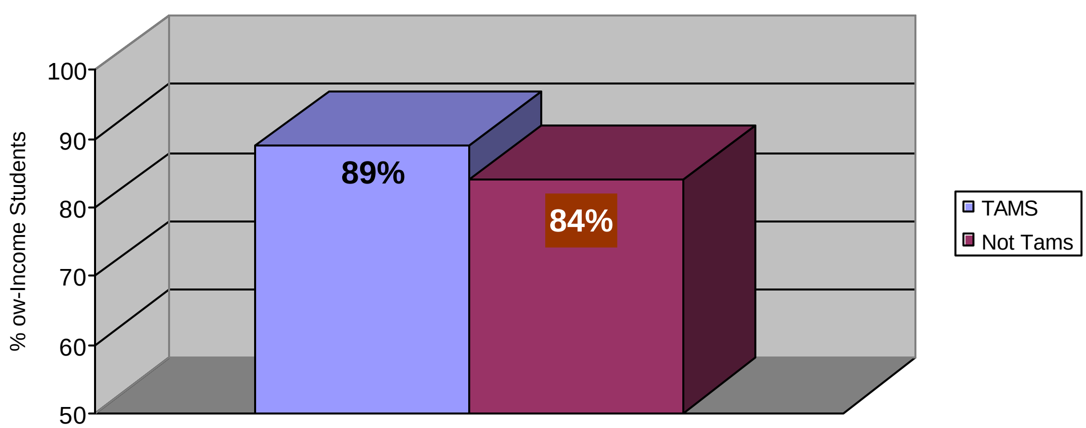
2.2) Chicago Comparisons

The Chicago Public Schools (CPS) is the third largest school system in the United States. CPS serves approximately 450,000 students in over 600 schools. Of this about, 345,000 students are in grades K to 8 in approximately 500 schools.

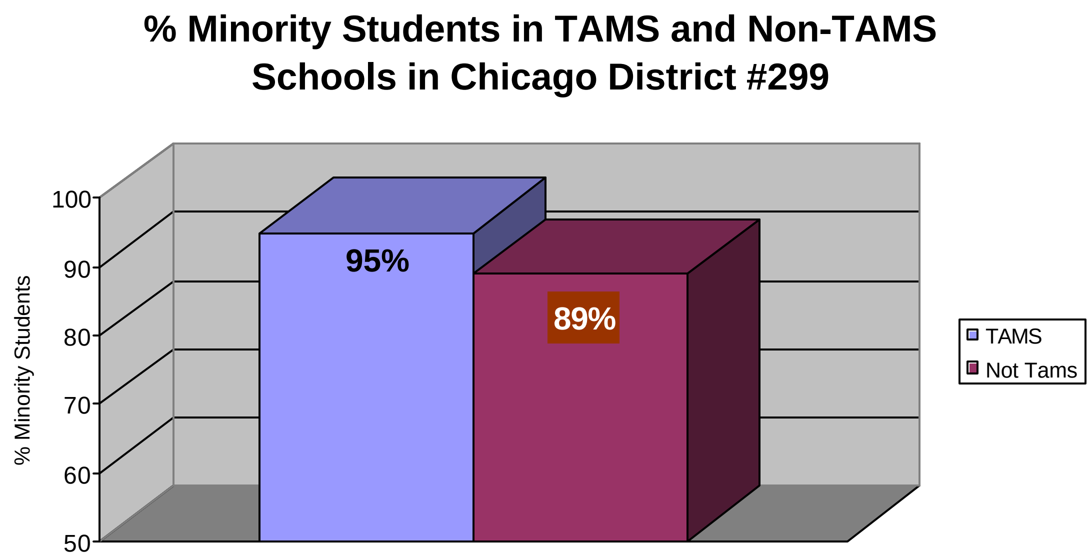
Compared to other public schools in Chicago, CPS schools served by TAMS have higher proportions of students from low-income families and minority students. CPS schools served by TAMS have about the same proportion of students with limited English proficiency as other CPS schools. They also have attendance, mobility and truancy rates that are about the same as other CPS schools. On average:

About 90% of the students in TAMS Chicago schools are from low-income families. In Chicago non-TAMS schools about 85% of the students are from low-income families.

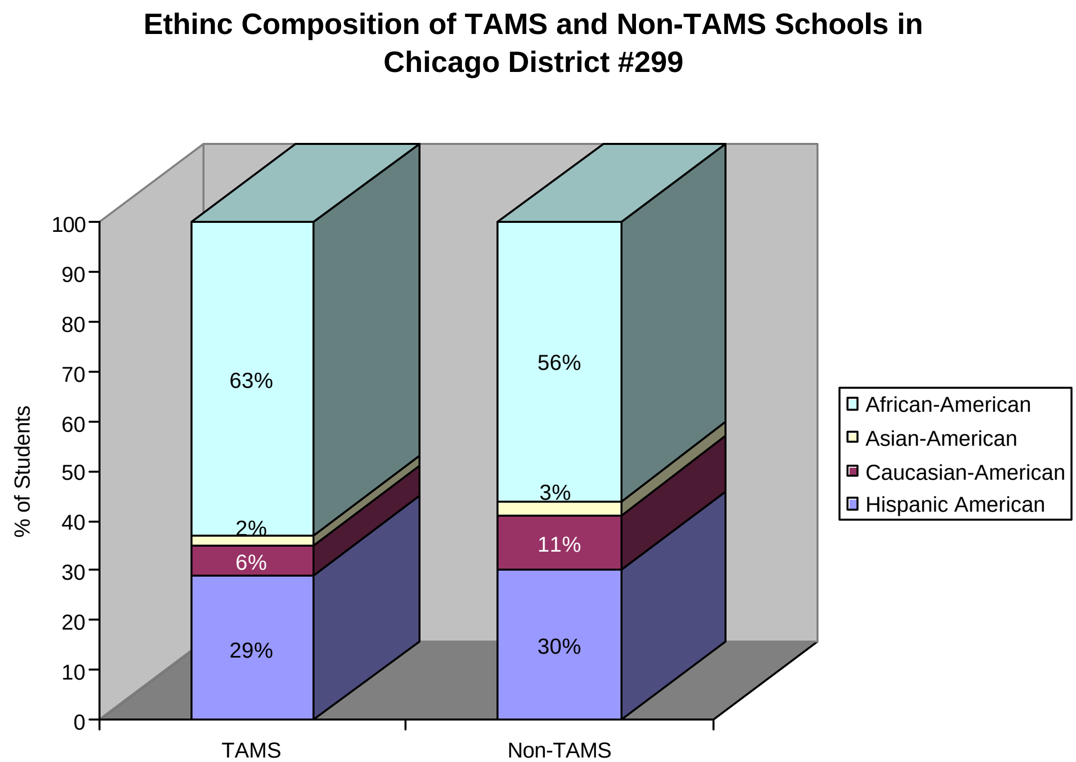
% Students from Low-Income Families in TAMS and Non-TAMS Schools in Chicago District #299



- 95% of students in TAMS Chicago schools are from minority populations as compared to 89% in other CPS schools.

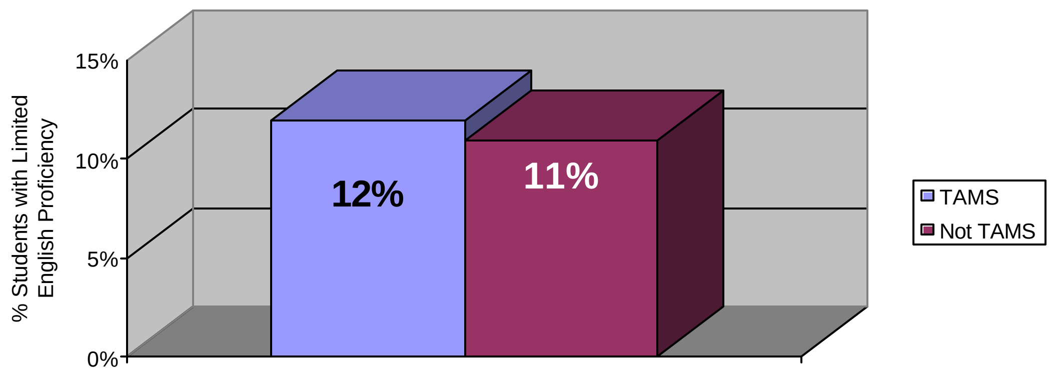


The difference in the minority populations of TAMS Chicago schools and other schools in the District is largely attributable to the higher percentage of African-American students in TAMS Chicago (63%Vs. 56% in other schools in the Chicago District).



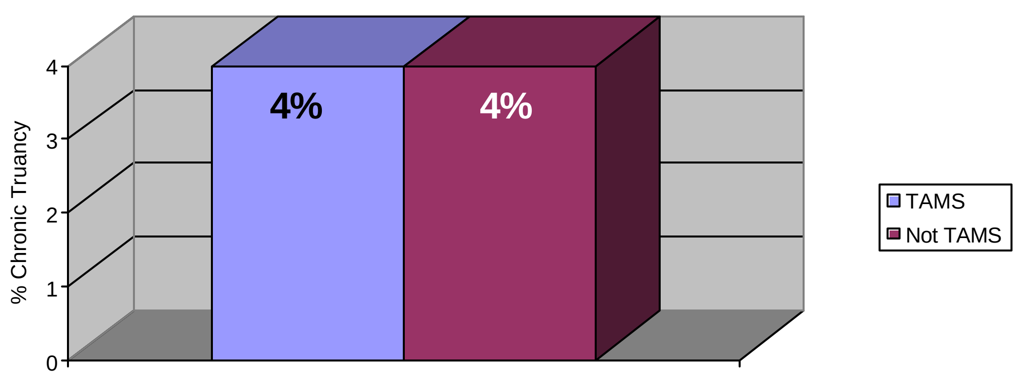
- 12% of students in CPS schools served by TAMS have limited English Proficiency as compared to about 11% in other CPS elementary and secondary schools.

% of Students with Limited English Proficiency in TAMS and Non-TAMS Schools in hicago District #299



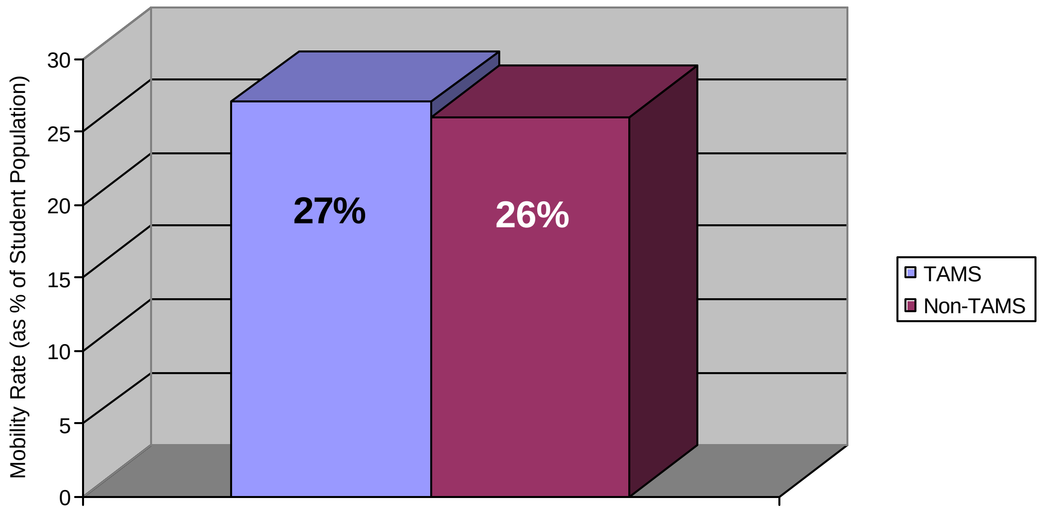
- The truancy rate in TAMS Chicago schools is 4%. This is the same as that in other schools in Chicago.

% Chronic Truancy in TAMS AND Non-TAMS Schools in Chicago District #299



- The mobility rate TAMS Chicago schools is 27% as compared to 26% in other CPS elementary and middle schools.

Mobility Rates in TAMS and Non-TAMS Schools



Section III Inquiry Based Learning: How We Do It at TAMS

From inception the TAMS program has focused on the national and state mathematics and science standards and has emphasized hands on, inquiry based instruction. These standards have provided the motivation to continue to move teachers toward inquiry based learning. The Content Standard for Science as Inquiry, for example, states, "As a result of activities in grades K – 12 all students should develop abilities necessary to do scientific inquiry and understandings about scientific inquiry."

In this work, TAMS first had to have a clear idea of what inquiry meant. According to the standards,

> "Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p.23)

Many of the workshop hours are spent helping teachers develop these abilities because this is not what is happening in their classrooms. Most of the teachers have had very little experience with this method of instruction. In fact, many teachers come with a fear of science and a dread of trying to carry out any kind of inquiry based endeavor. Moreover, it is common for the professional developers to hear teacher claims that these activities will not work with their students because they are too difficult.

At TAMS, work with hands on, inquiry based instruction begins in the very first sessions at all grade levels. All participants agree that mathematics is the tool of science and that is where instruction begins. As you examine the abilities that students need to have to carry out inquiry based science, you will find that a few of these abilities have their origins in two of the mathematics standards. These two important content topics are data analysis and measurement. Due to the importance of these two topics, some of the first workshops with teachers in the early grades are centered around sorting, classifying objects, data collection and creating some simple graphs, generally picture or bar graphs. In the later grades, time is also spent on data collection activities including experiences with sampling. Measurement activities are included at all of the grade levels. The topics of length, area and volume are studied in the very early grades whereas mass and density are emphasized in the later grades.

Movement toward more science oriented topics begins during first year workshops. The first one introduced to teachers is one that focuses on observation. This has shown itself to be very popular with teachers at all grade levels. Years ago this lesson centered on snails that were brought into the classroom for students to observe on a first hand basis. Today snails are no longer available. However, because the topic covered by the snails' lesson is so important in all of the grades other workshops were created to address this topic. In the early grades, this workshop emphasizes only observation. In the later grades, there is also discussion about making inferences.

Along with these preliminary lessons, there is one other set of activities that is introduced to the teachers. These are the TIMS laboratory lessons. These lessons were developed by Howard Goldberg at the University of Illinois. TIMS stands for Teaching Integrated Mathematics and Science. These laboratory activities take some of the skills that the students learn in data collection and measurement and give them a chance to apply these skills in a laboratory type experiment. These lessons start to address the process of science. Teachers learn that TIMS labs are carried out in a four step process that can be duplicated in studying other phenomena. This is referred to as "TIMSifying" an activity. Although this process does not have the teachers doing a truly inquiry-based laboratory experiment, it does bring teachers closer together by having them apply many of the skills that they have acquired so far. In the TIMS four step process, students first draw a picture of the activity that they are going to carry out. This means that the teacher has had to carefully explain what is going to happen so students can draw their pictures and label all of the parts. This approach helps teachers and students understand variables and which data to collect and graph. Next students conduct the experiment and collect the data needed. The data is entered into a chart and a graph is created.

After this, students have questions to answer. Some of these questions are directly related to the graphs students have created. Others require students think beyond those graphs and apply some of the knowledge that they have acquired. Some of the questions would be a good start for an investigation that would create a whole new problem to investigate. In the higher grades more emphasis is placed on formulating a question or hypothesis and then testing it out.

As the TAMS curriculum is carried out, some problems are encountered. Generally the problems come from the teachers themselves rather than the students. Many teachers are so fearful of science and even mathematics that they struggle to let students find out information on their own. Many of these teachers do not want to give up any control, and this is where the implementation portion of the TAMS program is so important. When teachers see children doing experiments and hear them coming up with their own questions, they do begin to see how beneficial the method is. When teachers are allowed to try some new activity, with a professional developer present to help them if things get out of control, the teachers grow quickly and become more willing to try other new things. As the two years progress, the topics such as the properties of matter, magnetism, force and energy, and position and motion are addressed. Each topic is addressed by using the focus of scientific inquiry and building on the skills that have been previously learned. At the end of the second or third year when TAMS is ready to leave the school, TAMS tries to have mechanisms in place to encourage teachers to continue their growth. This is done by fostering leadership at each grade level at the school.

Section IV Quantitative Evidence

4.1) Assessing Program "Effects"

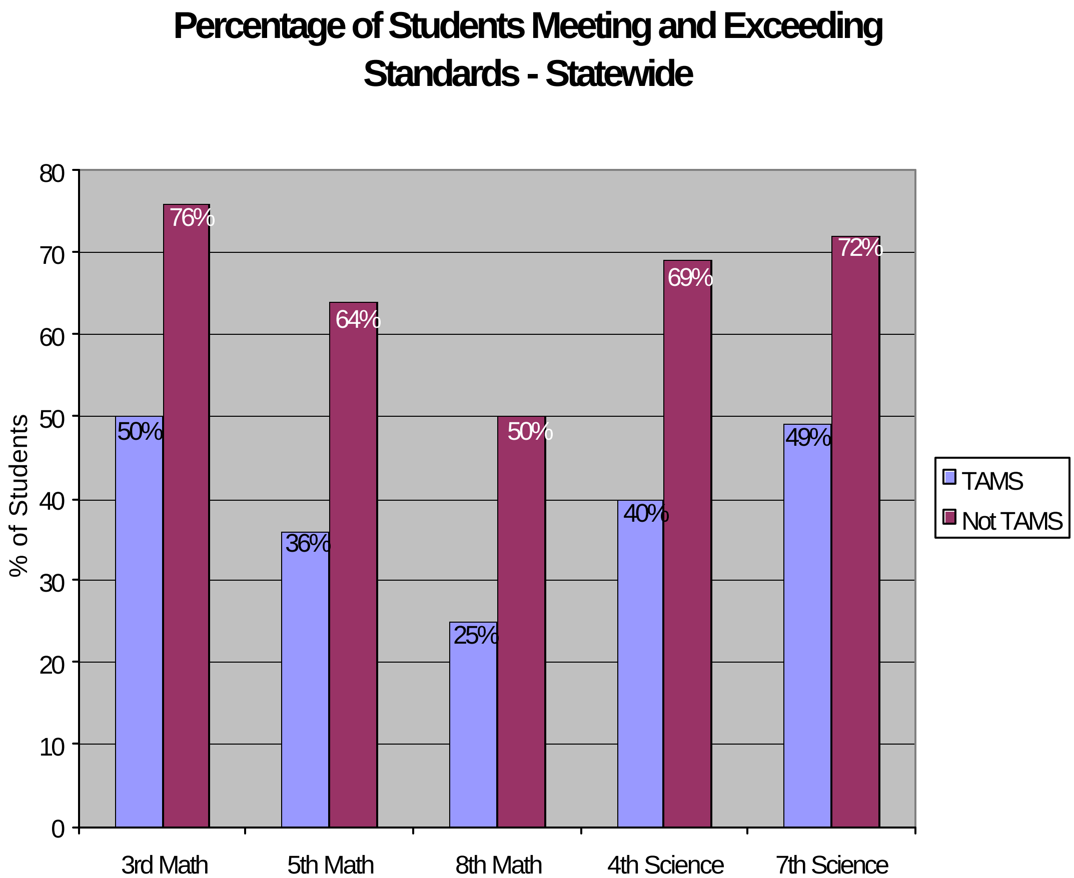
In discussing the *"Effect"* of the TAMS program, it is important to note that the *"Effect"* has at least two components. The first is the "*Effect"* the program has on teachers. This takes the form of changes in content knowledge, teaching techniques and orientation. It concerns not only changes in the amount of additional content knowledge teachers acquire, but also changes in their application of standards based curricula in mathematics and science, their use of best practices, and their use of a variety of instructional strategies to address the different learning needs and styles of students in their classrooms. The second component of the program's *"*E*ffect"* concerns its impact on student learning. In essence, this component of the program's *"Effect"* focuses on how well teachers transfer the knowledge gained through their participation in TAMS coursework and how effective they are in using the new teaching skills developed in the courses to increase student learning. This is measured by changes in standardized test scores and changes in the percentage of students meeting or exceeding standards.

The process through which content knowledge, pedagogical skills, and attitudes toward learning and teaching are transferred from Professional Developers (PDs) to teachers is referred to as "Stage I Transference". The Academy uses pre- and post-program "Teacher Skills" and "Attitude" tests to directly measure "Stage I Transference". Stage II Transference refers to the process by which teachers use their gains in content knowledge and improved pedagogical skills in transferring knowledge to students. Stage II Transference is from measures of student performance on standardized tests. Using a number of different measures of student performance, the Academy has amassed a considerable body of evidence that shows teacher participation in the program is correlated with increased student scores on State standardized tests.

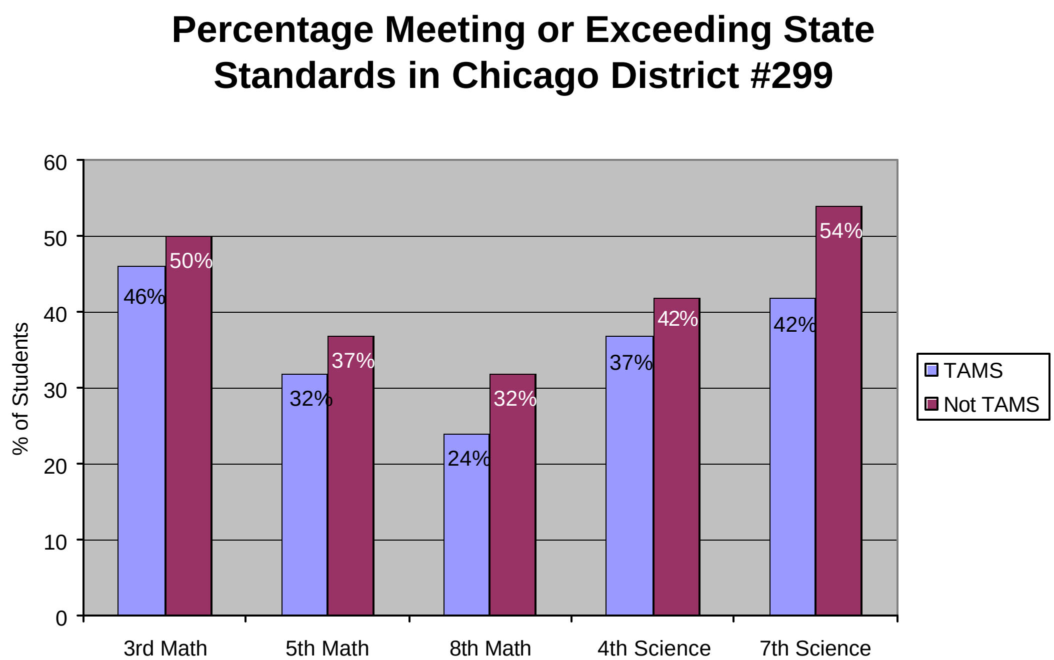
Much of what the Academy has learned from its experience working in Illinois schools and much of what it has learned in analyzing the data it has collected is not covered in this overview. Rather, this review focuses on the research and empirical evidence supporting the effectiveness of the program. Issues related to the conditions under which the program has been found to be most effective are not addressed. Briefly, however, the data indicate that the programmatic impact is greater in the lower grades. The *effect* is greater in districts outside Chicago, where both student and teacher mobility are lower. It is also greater in smaller schools (less than 700 students) than in larger schools, and is greater in schools where the school administration strongly endorses the program as opposed to giving only tepid support to the effort.

4.2) Percentage of Students Meeting or Exceeding Standards

The following chart illustrates the performance gap between Academy and non-Academy schools statewide. While statewide the percentage of students meeting or exceeding mathematics standards in 3^{rd}, 5^{th} and 8^{th} grade are 76%, 64% and 50% respectively, in Academy schools these percentages are 50%, 36% and 25% respectively. Similarly while the percentages of students meeting 4^{th} and 7^{th} grade science standards statewide are 69% and 72% respectively, the percentages in Academy schools are 40% and 49% respectively.


Percentage of Students Meeting and Exceeding Standards - Statewide
% of Students
80
70
60
50
40
30
20
10
0
76%
50%
64%
36%
50%
25%
69%
40%
72%
49%
3rd Math
5th Math
8th Math
4th Science
7th Science
TAMS
Not TAMS

The gap in performance between Academy and non-Academy schools in Chicago is much smaller. However, even in Chicago District #299 Academy schools consistently have lower proportions of students meeting or exceeding state standards. This is true for both math and science.

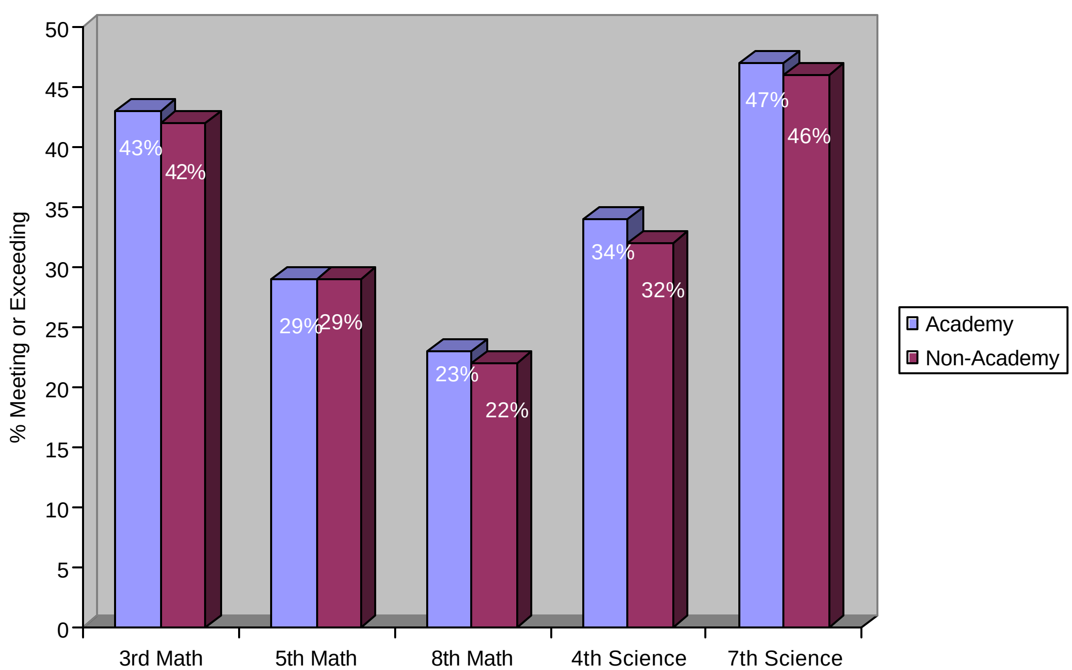


4.3) Academy Performance

In light of these differences, the progress made by teachers and students in Academy schools is impressive. Improvements within the Academy schools can be shown to occur across a variety of areas and measures.

For example, when we look at similarly situated schools in District #299 that is schools servicing student bodies in which 75% or more of the students are minority and 75% or more are eligible for assistance through the federal free and reduced lunch program, a different picture begins to emerge. In these schools, the situation is reversed. The percentage of students in Academy schools meeting or exceeding state standards in both math and science is equal to or exceeds that in similarly situated Chicago schools.

Percentage Meeting or Exceeding State Standards in Similarly Situated Chicago Schools

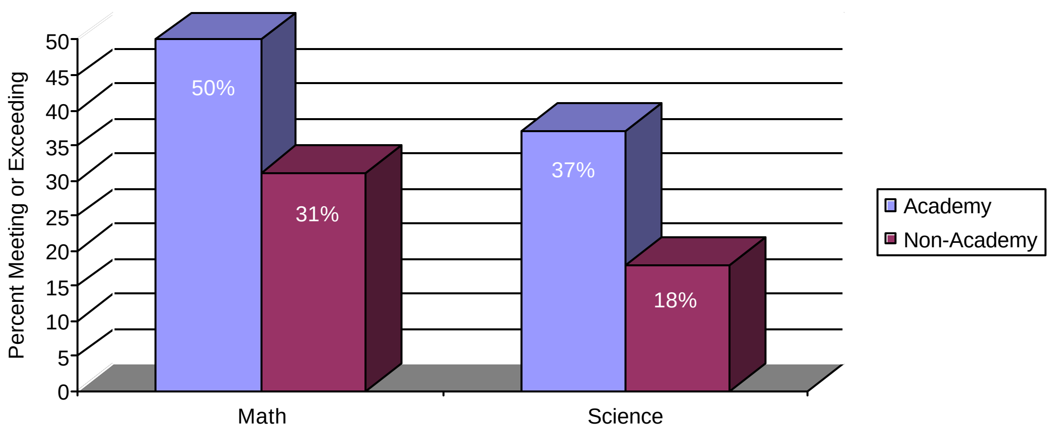


4.4) Change Over Time

Another way of assessing the Academy *effect* involves examining change in student performance over time. The following charts illustrate changes in student performance in seven downstate districts and in Chicago.

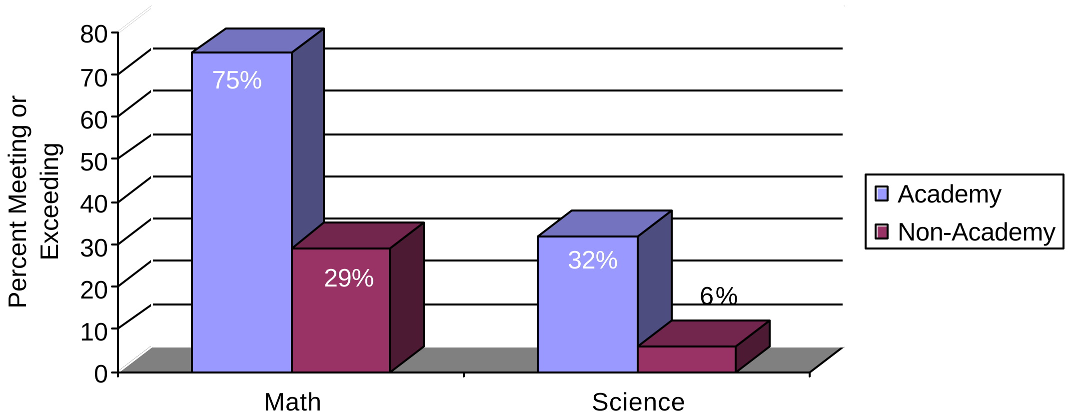
The first set of charts compares the percentage increase in the combined 3rd, 5th and 8th grade students meeting mathematics and 4th and 7th grade students meeting science standards in similarly situated Academy and non-Academy schools in Chicago District #299 for the period 1999-2002. The charts below show Academy schools posting proportionate increases in the percentage of students meeting or exceeding standards of 50% and 37% in mathematics and science respectively, while non-Academy schools are seen to have posted less dramatic gains of 18% and 31% in mathematics and science.

Proportionate Increase in % of Combined 3rd, 5th and 8th Grade Students Meeting or Exceeding Illinois Math and 4th Grade Science Students Meeting Science Standards in District #299 (1999-2002)



The next set of charts shows the same data for mathematics and science for the 1999-2002 period in the seven downstate school districts in which the Academy worked. These charts show Academy schools outside Chicago posting increases of 75% and 32% in mathematics and science respectively, while similarly situated non-Academy schools outside Chicago show gains of 29% and 6% in math and science respectively.

Proportionate Increase in % of Combined 3rd, 5th, and 8th Grade Students Meeting Illinois Math and 4th & 7th Grade Science Standards (1999-2002) in Seven Non-Chicago Illinois School Districts

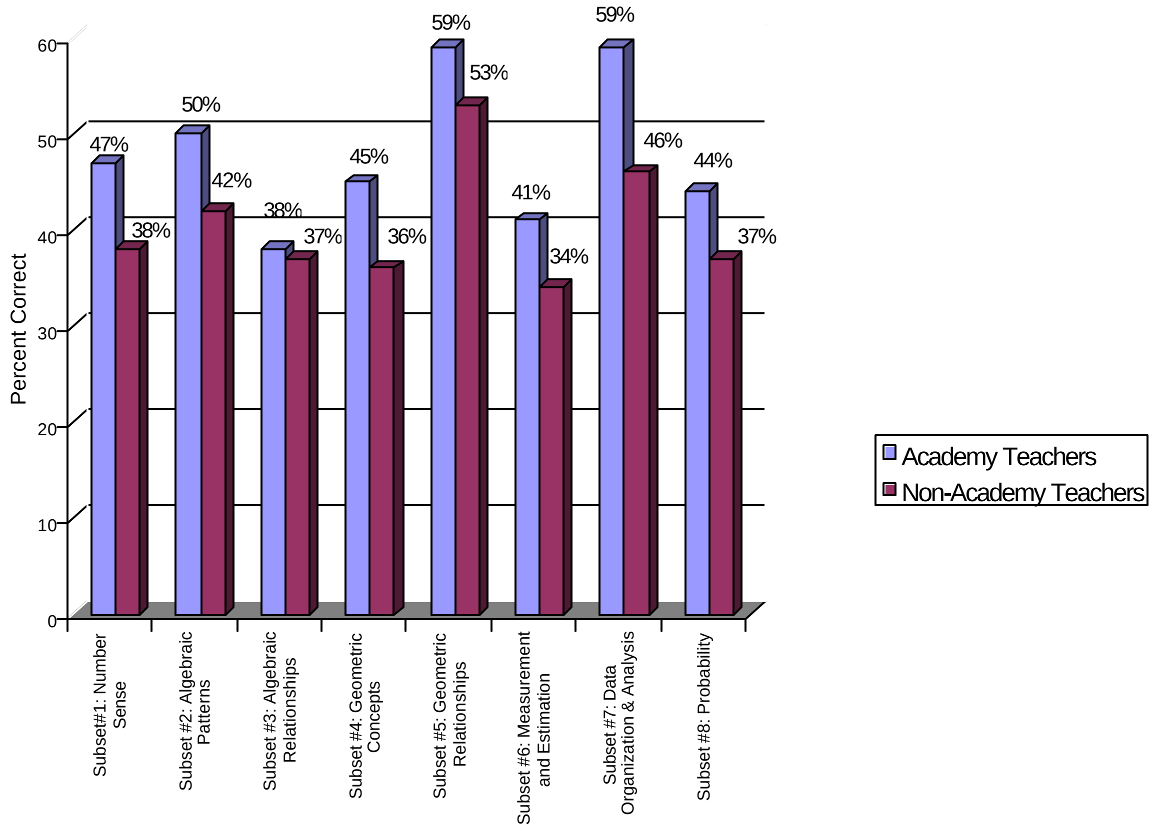


4.5) Same School Comparisons

An alternative way of viewing the Academy e*ffect* is to look at the performance of students taught by Academy teachers to that of students taught *in the same school* by teachers who did not participate in the Academy program.

Using the Illinois learning standards as a framework, the following chart shows that in Chicago for each subset examined students taught by Academy trained teachers answered a higher percentage of questions correctly than did students in the same schools who were not taught by Academy trained teachers.

Same School Performance of Primary Students in the 1999-2000 Chicago Cohort of Academy Schools by Math Subsets in 1999-2000



4.6) Controlled Regression Models

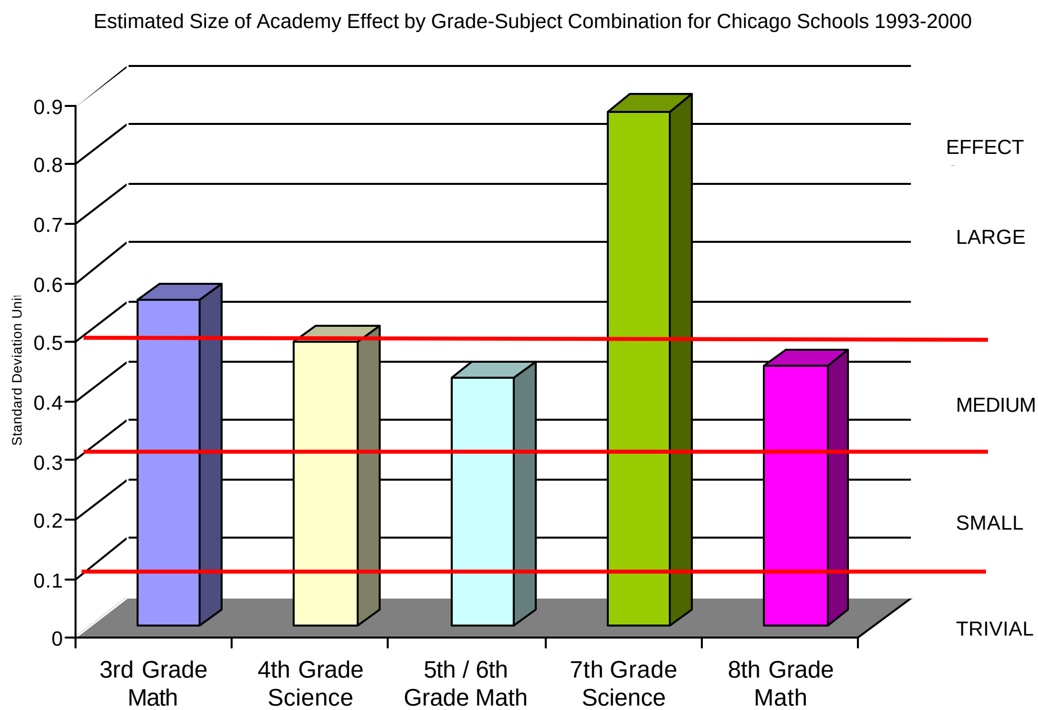
A more stringent test of the Academy *effect* on student learning involved the use of multivariate statistical tests. The Academy used a multiple regression analysis to examine the program's impact on both school and student test score performance. The use of regression allowed the Academy to control statistically for a variety of other conditions that could influence test performance. This was done using a "value-added methodology".

The "value added methodology" determined a predicted performance outcome for each school controlling for a given set of external social and demographic characteristics. The external conditions controlled for included prior test scores, the size of the school, truancy and mobility rates, as well as the ethnic and income composition of the school.

In these school-level regressions the program's effectiveness was determined by how much a school exceeded or fell below its predicted score. This was done by computing predictive equations for each Academy cohort based upon data for schools that did not participate in the Academy program. The equations were then applied to Academy schools, and the unstandardized first order residual was used as an estimated or predicted score. The predicted score reflected an expectation of how a school might have been expected to perform had it performed like schools that had not participated in the Academy program. The predicted scores were then subtracted from the actual scores (A-E) and the differences were summed across schools and time. Grand means were computed. A positive difference indicated a school performed better than expected compared to CPS schools with similar initial scores and demographics.

The results of these studies show that across Academy cohorts and standardized tests (IGAP/ISAT and ITBS), 3rd grade math results are very positive for the Academy and 4th and 7th grade science results are strong. They also suggest that at the school level across all subject grade combinations (3rd, 5th, and 8th grade math and 4th and 7th grade science) and across all years (1993-2003) Chicago Academy schools do better than similar non-Academy schools on state standardized assessments. Over the time period covered by these analyses the studies suggest about 18,000 more test takers in Academy schools met or exceeded standards than in non-Academy CPS schools with similar characteristics.

The results of multivariate analyses involving 479 CPS elementary schools; 87 of which completed the Academy program are presented in the chart below. The chart presents the size of the Academy *effect*. The *effect size* is measured in terms of standard deviation units (SD) and as a rule of thumb an effect size less than .01 is considered "Trivial", .01-.30 SD is "Small", .30-.50 SD is "Medium" and greater than .50 SD is "Large" (Rosenthal & Rosnow, 1984). In the chart we find medium to large effects for the Academy program in each grade subject combination.



Similar regressions using student-level data have yet to be completed. These analyses present a number of unique challenges. Foremost among these is the difficulty linking individual test score performances over time. This problem centers on the lack of a statewide universal student identification system. The lack of such a system makes it impossible to link student test scores over time. As noted earlier, the only area in the State where such a system exists is Chicago District #299, and this District presents unique problems. For example, mobility rates in the District are high. About 17% of the students change schools or leave the District each year. The staggered testing schedule for both math (3^{rd}, 5^{th} and 8^{th}) and science (4^{th} and 7^{th}) exacerbate the problem.

4.7) Sub-population Comparisons

This research was undertaken in the wake of "No Child Left Behind" (NCLB) legislation. NCLB brought with it a new focus on sub-populations and the provision of services to these populations. This led the Academy to undertake an assessment of the program's impact on male and female students as well as an assessment of its impact on ethnic populations. The study is based upon student level data and follows the same student cohort overtime.

This same student study examined changes in the percentage of students who began 3rd grade in the1997-1998 academic year, remained in the District (Chicago #299), and took the 5th grade math test two years later (2000-2001). The study also looked at changes in the percentage of students who began 3rd grade in the1999-2000 academic year, remained in the District (Chicago #299), and took the 5th grade math test two years later (2001-2002). This design allowed the Academy to compare changes both within and across cohorts for the same population of students. A similar analysis was undertaken for 4th to 7th grade science for students who started 4th grade in 1997-1998 and took the 7th grade test 4 years later (2000-2001). Comparative data for students who started 4th grade in 1999-2000 were not available at the time, since these students were not scheduled to take their 7th grade science exam until academic year 2002-2003.

Each subgroup (Male/Female, and Hispanic, Caucasian, African American) were classified into one of two groups. These were students in Academy schools taught by Academy trained teachers and students in Academy schools taught by non-Academy trained teachers in the initial grade (3rd for math and 4th for science). By using the change in the percent of students meeting or exceeding State standards rather than test score performance circumvented the problems resulting from the change from the IGAP to the ISAT. Percentage point differences were used in several ways to analyze the data.

For each group the percentage point change between periods and across groups were used to examine how the same students performed at two points in time (for example, 3rd to 5th grade math). They were also used to compare how different groups of students performed (Academy taught Vs non-Academy taught), and to compare how different classes of students performed (Male Vs Female). With respect to 4th to 7th grade science this research found Academy boys outperformed Academy girls and Academy African-American students out performed the Academy's Hispanic and Caucasian students with respect to the change in the percentage of students meeting or exceeding State science standards.

In the case of 3rd to 5th grade math, the Academy's 1998-1999 cohort began 3rd grade with an advantage in math over their non-Academy counterparts. They built upon those advantages in 5th grade. By contrast, the Academy's 2000-2001 cohort began the period at a disadvantage relative to their non-Academy counterparts and closed the gap considerably.

Section V Qualitative Evidence

The numerical data that TAMS has gathered over the years suggests the TAMS program has been effective in schools throughout Illinois. This, however, is not the only kind of evidence that exists. There is also qualitative evidence supporting these findings. The Academy's professional developers have collected this evidence over the years. The evidence is based upon the recorded observations of PDs working in schools. As noted earlier, PDs record their observations and information about their experiences in an electronic database the Academy has developed for this purpose. Prior to the development of this electronic database, this information was recorded and hand-written into paper logs maintained by PDs. The following comments are common, albeit not ubiquitous, in these logs.

1. Teachers attempt lessons that they would not have tried before.
2. Teachers give students more time to explore when using manipulatives and understand the importance of hands-on activities.
3. Teachers learn to take time to think, let the students think, slow down, let the students inquire without too much interference, and take lots of time for reflection.
4. Students that have trouble in reading, sometimes out-perform some of the other students.
5. Teachers see their students become more lively and excited when involved in hands on activities. Conversations that are focused on the activities are observed.
6. Students that were not interested in any classroom activities, are now interested in these inquiry based lessons.
7. Teachers move from having a low comfort level with implementing new activities to being eager to try a new activity.
8. Cooperative group skills used in mathematics and science activities are used in other subject areas.
9. Teachers incorporate graphing in more areas of their science and mathematics lessons.
10. Students extend their own knowledge by replicating investigations or rebuilding models at home.
11. Teachers begin to create different ideas for analyzing information for the science kits that they are using.
12. Some teachers choose to continue on and take courses so that they are able to obtain endorsement in mathematics or science.

Changes sometimes are small, but even these changes are important. When a new group of teachers begins the program, they come expecting quick fixes. By the second year of the program, they learn that their lessons build on each other and that they need to have a longer term approach.

One change that seems small, but has dramatic implications is the classroom arrangement. Frequently in the first year, the professional developer finds the classroom set up in rows in columns rather than in groups. When the professional developer arrives, desks are moved to facilitate students working in groups. Many times by the second year of the program, the professional developer discovers the teacher has the students in groups for all subjects.

Sometimes the motivation to change comes quickly as it did with one 5^{th} grade Chicago teacher. She and a parent/aide were so impressed with the Academy's science camp that they came back and started a whole fifth grade project. This project combined two classrooms to observe and study the confluence of the Chicago River, Bubbly Creek and the Canal to the Chicago River. At the end of each year the graduating fifth grade class would share their progress and would work one day with their parents and the next day with the incoming 4^{th} grade students. With the help of one of the Academy's professional developers, the students did fresh water biology studies and terrestrial ecology studies.

Over the course of several years they initiated numerous clean-ups and studies of an area dumpsite. They initiated a letter writing campaign and had a dumpsite removed. The Chicago City Council recognized their work by making the fifth grade class stewards of 3 acres of land at the dumpsite. They continued their project by designing a park that later the Chicago Park District would help build. Today, nine years later, the school's fifth grade classes continue their study of the park and land, and, even though the teachers have moved away, the work continues to be facilitated by the new teachers.

People often think that it is easier to change new teachers because they have only taught a short time and have not yet developed many poor habits. However, one bilingual teacher who had a $3^{rd}/4^{th}$ grade split class requested investigation lessons for each implementation visit. She wanted these lessons to give her students a chance to catch up. The students read thermometers, used balances, measured liquid volumes in graduated cylinders, and measured with meter sticks. They learned the processes of science and how to gather and analyze data whether they spoke Spanish or English.

Many times the change is gradual as with this Chicago teacher. This teacher taught 7^{th} and 8^{th} grade science. The professional developer described her as a teacher working the text curriculum as it existed along with two unrelated texts in an uncoordinated fashion. The teacher was trying to guess what should be taught to her students in order to raise their state test scores. During the first visit to her classroom, the professional developer noted that she had good control of her class but that the lesson lacked the structure of scientific methodology and inquiry-based activities. The PD felt the teacher needed to learn to engage the students and to do data collection activities.

After a few visits, the teacher recognized the importance of teaching students how to record data in tables. She also learned the importance of having students make predictions (or hypotheses), and she also recognized that these skills could be carried over to language arts and social studies.

After the first year, the PD observed that this teacher had made great progress in understanding constructivism and scientific methodology and in improving student skills and knowledge through hands on activities.

This teacher is currently completing her second year in the Academy program. She started out the year with a full quarter of strictly inquiry-based activities focusing on the TIMS process and the scientific method. Content was taught but inquiry, constructivism and the scientific method were the focus. The story does not end there.

Now at the end of the year, a sixth grade student, who worked with this teacher, was judged to have the best 6^{th} grade project in the regional science fair, and an 8^{th} grade student received second place at the same fair. These two students were the first students in many years to receive any award for this school at this regional science fair.

Through the classroom visits professional developers have found that there are changes taking place that are not picked up in the quantitative assessments, and these changes are important nonetheless. The changes are not the kind that appear in our collected data, but they suggest that teachers are beginning to understand the importance of inquiry in their classrooms and are trying to move in that direction.

Section VI Research and Data Issues

6.1) Research Background

In 1997, a small group of social scientists and statisticians undertook the task of documenting the *"Academy Effect".* This effort began on two fronts. The first focused on documenting *the effect* on teacher learning and attitudes. Much of this effort focused on teacher specific data that had been collected via the biographical forms, attitude surveys, and skills tests. The emphasis was on the development of measuring instruments and testing of the reliability and validity of these measures in different geographical environments and over time. The second front focused on student test performance data and the program's impact on student learning.

The Academy's quantitative inquiries have used three basic types of data in documenting the Academy effect. These were school level data, student level data and teacher level data. The fundamental problem with the school level information is that not all teachers in a school participate in the TAMS program. Hence, these analyses are subject to the criticism that observed changes may simply be the result of improved performance by student taught by non-TAMS teachers. The classroom analyses, however, suggest this is not the case. When students <u>in the same school</u> taught by Academy trained and non-Academy trained teachers were compared, students taught by Academy trained teachers were found to have answered more questions correctly in every subset of the ISAT mathematics test than students taught by non-Academy trained teachers. The classroom analyses are also subject to criticism. The data are limited to Chicago District #299 and not all of the records for Academy schools are present in the database.

Pre and Post Intervention analyses have been conducted among teachers and students. The pre/post analysis conducted among teachers indicates that teachers gain in content knowledge after exposure to the program. Most of this gain occurs during the first year of the program, and the results are geographically consistent across the State. These studies are not without their shortcomings. They fail to adequately control for all relevant variables. There may be testing effects and one could argue the results are a function of social process that result in a "culling of the cream" effect.

The Academy also uses pre-post comparisons in assessing program effects on student performance by comparing changes in the percentage of students in Academy schools meeting or exceeding state standards at different points in time and contrasts these changes with similar changes in non-Academy schools. The results of these studies have shown a fairly consistent pattern of gains among Academy schools as compared to their non-Academy counterparts. Important disadvantages to this approach include the failure to control for other variables and the fact that the comparisons are "same grade" comparisons rather than "same student" comparisons.

Controlled multiple regression models using school level data have found a link between participation in the Academy program and test scores. Moreover, these studies have demonstrated the relationship exists even when previous test scores, mobility rates, ethnicity, income, and truancy rates are controlled.

6.2) Teacher Data

At the outset of the program each participating teacher is asked to complete a biographical profile, an attitude survey as well as content skills tests in mathematics and science. At the conclusion of the first program year and again at the end of the teacher's second year of program participation, each teacher is again asked to complete an attitude survey and content skills tests in mathematics and science. These data are, in turn, supplemented by qualitative field data collected through a series of "implementation logs". The Academy's professional developers completed these logs following each in-class demonstration session with a teacher.

The testing sequence allows the Academy to establish a quasi-experimental "pre-test/post-test" design. This design is used to assess whether the mathematics and science content skills of teachers participating in the program change over time. The Academy does this by comparing pre and post program scores on the content and attitude surveys. These comparisons allow the Academy to assess the direction and magnitude of change in teacher learning and attitudes overtime. However, the approach is subject to criticism on at least two levels.

First, one could argue the design fails to account for the influence of individual differences between teachers such as differences in educational attainment, ethnicity, years teaching, etc. Second, one can also argue the design fails to account for the influence of extraneous factors. These factors might involve things such as additional educational courses a teacher might be enrolled in during the period, programs sponsored by the local District administration or particular school in which the teacher is working, union initiatives to improve teacher performance, and the like. Although the Academy has undertaken a series of factor analytic studies in testing the reliability and validity of these instruments over time and in different geographical areas across the State of Illinois, it has yet to empirically subject the data to a multivariate controlled investigation. Using the biographical data collected from teachers as independent predictor variables would go a long way toward addressing the argument that the design fails to account for the influence of individual differences among teachers or between different cohorts of teachers participating in the program. Resolution of the second criticism concerning the impact of extraneous factors is more difficult. The inability to adequately address this latter concern undermines the Academy's ability to causally attribute observed changes in teacher skill levels and attitudes directly to the program.

6.3) Student Data

Unquestionably, the bulk of the Academy's effort in documenting the program's effect has been focused on student performance. The outcome of this effort has told us more about the difficulty of conducting real world analyses than it has the impact of the program itself. If there is any single overriding finding to come out of this effort it is there is no simple unquestionable empirical approach using existing data on student and/or school level performance on standardized tests for documenting the *Academy Effect*. This is as much a result of the dynamic and fluid nature of the testing process in Illinois as it is a consequence of the shortcomings of alternative research designs themselves.

Illinois Educational Data

There are approximately 1.2 million public elementary and middle school children in Illinois, and there are about 140,000 to 150,000 students in each grade tested (3^{rd} through 8^{th}). Each year the Illinois State Board of Education (ISBE) publishes data on the test scores of students who took the Illinois State Achievement Test (ISAT) as well as school level summary statistics for these data.

The Academy obtained access to both the student and school level test score data for the period 1990 through 2003, and spent about 4-6 months constructing a longitudinal database for students tested during this period. Prior to this effort, no database for tracking same student performance on these tests over time existed within the State. The databases that did exist were designed for summarizing data annually. Each year was treated separately. When multiple years of data existed in a single database, the data were simply stacked vertically. This did not allow same student performance to be tracked overtime. The same was true for the school level summary statistics published by the State.

In constructing its longitudinal database of student test scores, the Academy found its efforts limited by the absence of a universal statewide identification system for students. Although State data files provided a data field for student identification numbers, school districts were not required to have such a system. What was entered in the field (if anything) was up to the district. The State lacked a statewide identification system that could be used in tracking student performance overtime. There was also no assurance that individual school districts within the state had developed their own numbering systems. If such systems existed at the district level, the State had no policy to ensure the id numbers associated with each student would be recorded by the district in the data field provided for this purpose. This shortcoming made it impossible to construct a statewide longitudinal database of individual student scores over time.

Chicago District #299 is the only large district in the State to maintain and consistently report its student identification numbering system over time and District #299 is by far the largest school district in Illinois. The District serves approximately 400,000 to 450,000 students. The Academy constructed a longitudinal database for all students tested in Chicago between 1990 and 2003. The utility of this database, however, is limited by CPS personnel policies, the dynamic nature of the testing process, the structure of the process and the evolving nature of the Academy program over time.

As a general rule, State and District #299 files do not provide information that allows students to be linked to teachers. This is part of a broader district policy involving union issues related to teacher privacy, as well as to prohibit the use of these data in research designed to evaluate or rate teacher performance. The Academy, however, was able to circumvent this problem to some degree for one investigation. The Academy did this by physically obtaining paper copies of the roster for each school it had worked with. These rosters identified the classroom to which a teacher was assigned. The data was cleaned, coded and an SPSS system file was constructed. Data files from District #299 containing student classroom assignments were obtained and a merged file linking students and teachers to one another via classroom assignments was constructed. The process had its shortcomings.

For example, not all teachers had specific classroom assignments. Some schools were organized departmentally such that teachers taught students in different classrooms. The Academy was not able to obtain the necessary rosters for all schools because too much time had past and the paper copies of the rosters had been destroyed. Some teachers who had participated in the Academy program were not math or science teachers at all, but had attended the Academy to either meet the 80% requirement or because they had particular personal interest in the program. Some teachers left midway through the year and were replaced by teachers who had not attended the Academy program. The entire process of linking students to teachers was long and arduous. It took about two months to obtain the rosters and it took two interns an entire summer to code the clean and code the data.

Students are not tested annually in mathematics or in science in Illinois. Rather, students are tested in mathematics in the 3^{rd}, 5^{th} and 8^{th} grades. They are tested in science in the 4^{th} and 7^{th} grades. This testing schedule makes longitudinal analyses difficult. In each instance at least two or more years have passed and students are exposed to one or more teachers between test administrations in mathematics and science. Since not all teachers are required to participate in the Academy program, there are no assurances that a student would be exposed to an Academy trained teacher in the intervening years. Hence, the scheduling of the testing program limits the ability to directly attribute changes in test score performance to the Academy program.

Moreover, since the first testing period for math occurs in the spring of the student's 3^{rd} grade year and the first science testing period occurs in the spring of the student's 4^{th} grade year, it is not possible to obtain a pure “pre-program” baseline measure. In the case of 3rd grade math students have been exposed to the program for about 6 months prior to taking their first recorded ISAT math test. In the case of science, a student may have been exposed to the program for anywhere from 6 months to a year and 6 months.

Further, the test used and testing grades were found to not have been consistent over time. Previously, for example, Illinois administered the mathematics tests to students in the 3rd, 6th, and 8th grades. This was changed to the current schedule of 3rd, 5th and 8th grades in 1998. Illinois also redesigned its tests in February, 1999. At this time, the State switched from the Illinois Goal Achievement Program (IGAP) to the current ISAT examination. In making the transition, the State phased the test change in over time. The switch from the IGAP to ISAT in mathematics was implemented first. The switch from the IGAP to the ISAT in science occurred the following year.

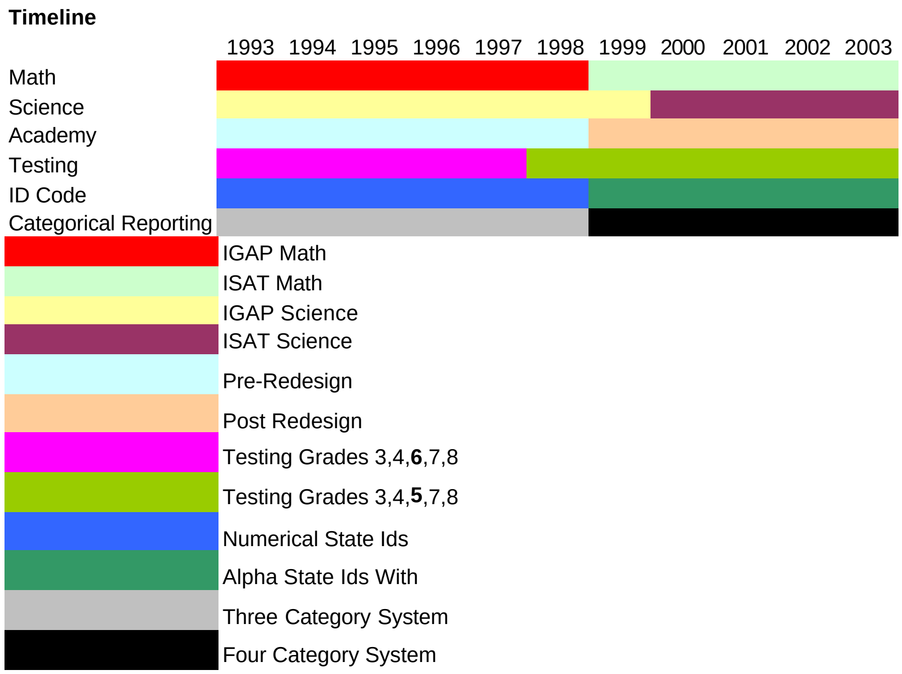
At the same time, the Academy did not see its program as static. The experience it gained over the years working in Illinois public schools led to a fundamental change in the program’s design. This “redesign” occurred in 1999. Hence, while the Academy was able to construct an extensive longitudinal database of student performance that could be used to track individual test scores over time, the utility of the database for such analyses was limited by the changing nature of the environment. This was also the case with the establishment of the school level files.

The construction of the school level database had the advantage of a fairly consistent numbering system for schools within the State. This facilitated the Academy’s ability to track school level performance over time. The utility of the database was undermined by many of the same factors impacting the use of the Chicago student level database, namely the change from IGAP to ISAT, the staggered implementation process used in making the change, the switch in testing sequences from 3rd, 6th and 8th grade to 3rd, 5th and 8th grade, and the 1999 redesign of the Academy program. The closing and reconfiguration of schools also impacted the school level database. Prior to 1999 every school in the State was assigned a 13-digit numerical identification number. With the advent and reconfiguration of schools as charter schools the numbering system changed to a 13-character alpha structure. This led to logistical problem in linking schools overtime and raised questions concerning the legitimacy of doing so, since the reconfigured school now operated under a different administrative structure. Moreover, some large schools were reconfigured as schools within schools. This raised questions concerning the legitimacy of treating the reconfigured school as structurally continuous over time.

Beginning in the spring of 1999 ISBE also began reporting only the percentage of students in each school that met, exceeded, or fell below standards. Prior to the 1998-1999 academic year ISBE school level files contained information on actual test score performance. With the publication of the 1998-1999 data this was no longer the case.

Moreover, the categories for classifying the percentages of students also changed. Prior to the release of the 1999 data the State had used a three-category system (Met, Exceeded and Did not Meet standards). With the release of the 1999 data the last group (“Did not meet”) was split into two groups - students whose scores simply fell below standards and those whose scores placed them on academic warning. The change was important because the use of four categories for classifying performance made some longitudinal comparisons incompatible.

The following figure graphically portrays the changes over time and illustrates the problems one confronts in undertaking longitudinal analyses of student test score performance in Illinois over the course of the decade between 1993 and 2003.



Section VII Analytic Designs

In responding to these issues as they arose, no single unambiguous overriding long-term longitudinal quantitative analysis documenting the *"Academy effect"* emerged. Rather, a more limited series of individual analyses addressing different aspects of the program's impact on student test score performance came to light. Each of these approaches had their own individual strengths and weakness, <u>but together the thrust of the findings of this research effort yielded a fairly consistent body of evidence supporting the hypothesis that the Academy program leads to improved student test score performance on State standardized tests</u>. This conclusion emerged largely from the triangulation of a variety of different methods and analyses.

7.1) Paired Comparisons

One means of identifying the existence of an *Academy Effect* involved the use of paired comparisons and descriptive statistics. Paired comparisons involve the comparison of Academy schools to non-Academy schools with similar demographics. The Academy used school level data to compare the percentage of students meeting and exceeding State standards in Academy and non-Academy schools. In making these comparisons, the Academy matched schools in terms of two critical variables – the percentage of minority students and the percentage of students from low-income families. This was done to control for differences between these two populations on these variables. The differences between the populations are a product of the Academy's targeted effort on schools serving low-income and historically disadvantaged students.

The advantage to this approach is in the simplicity of its design and presentation. The approach plays well among stakeholders who are not accustomed to highly quantitative multivariate analyses. The ability to present the findings of this research using simple percentages and bar graphs illustrates the existence of *an effect* and allows results to be communicated easily.

The disadvantages to this approach can be found in the failure to control for other possible differences between the populations, such as differences in initial levels of performance. The approach is also limited by the data itself. The findings are based upon school level data and not all teachers in a school participate in the Academy program and those that do may not remain in the school over time. Hence, it is not possible to causally attribute the observed *effect* to the program itself. Changes in test scores or in the percentages of students meeting or exceeding state standards could be the result of improved performance by students being taught by non-Academy trained teachers. The *effect* could also be the result of extraneous variables that are not controlled, for example, a change in school principals.

However, it is important to note that the results of these comparisons using school level data suggest the presence of an *Academy effect.*

7.2) Pre-Post Comparisons

Pre-Post comparisons involve looking at the same entity at different points in time. In documenting the *Academy effect,* the Academy used pre-post comparisons in several ways.

First, the Academy compared the pre and post program attitude and math and science skills test performance of teachers participating in the program. As noted earlier, the Academy did this by administering attitude, math and science skills tests to teachers prior to the onset of the program and again at the end of the first and second program years. The percentages of correctly answered questions at each administration were compared. These studies found teachers participating in the Academy program to post substantially higher scores on the mathematics and science skills tests after having participated in the program. The findings further suggest most of the growth in content knowledge occurs in the first program year.

One of the advantages of these comparisons is again found in its ease of presentation to stakeholders who are unaccustomed to highly quantitative analyses and presentations. The approach also has the advantage of providing a straightforward pre-post program assessment of growth in content knowledge among participating teachers.

These comparisons, however, have their disadvantages. Foremost among these is the inability to control for extraneous variables. All of the teachers participating in the program have lives outside the program. Many of these teachers are involved in other educational activities such as participating in Masters' Degree programs, District and/or school sponsored professional development activities, and the like. Hence, it is not possible to causally link the improvements in teacher performance on these math and science tests directly to participation in the Academy program. Moreover, teachers are asked to take what are essentially the same test repeated times. This leads one to question the presence of testing effects. That is to say, the improvement in scores may be the result of teachers becoming increasingly test savvy.
The fact that most of the improvement is teacher performance on these tests is seen to occur in the first year of the program, however, seems to run counter to this argument.

Another disadvantage to this approach arises from the structural nature of the program. Teachers are not mandated to participate in the program. In fact, some teachers find the time demands the program places on them incompatible with their other responsibilities. The Academy has found this to be an important reason why many teachers drop the program. Also, the Academy has a policy of dropping schools, which it feels are not meeting the program requirements for 80% or more teacher participation. Hence, it is possible teachers who drop the program or teachers from the schools dropped by the Academy are the poorest performing teachers. If this is the case, the observed increase in teacher performance on these tests may simply be a function of the dropping of the least qualified.

Second, the Academy uses pre-post comparisons in assessing program effects on student performance. It does this by comparing changes in the percentage of students in Academy schools meeting or exceeding state standards at different points in time. These changes are often contrasted with similar changes observed in non-Academy schools during the same time period. In making these pre-post comparisons with non-Academy schools, the Academy again uses a paired-comparisons approach in which the comparison schools have similar low-income and minority percentages.

The examination of change using a paired comparisons pre-post program design allows the Academy to compare differences in growth, where "growth" is defined in terms of changes in test scores or in the percentage of students meeting or exceeding state standards. The advantage again lies in the simplicity of presentation. Foremost among its disadvantages are the failure to control for other variables, the fact that the populations being compared are not "same student populations". Rather, they are based upon "same grade" comparisons.

7.3) Classroom Analyses

Another avenue of proportionate comparisons involves the classroom based study discussed earlier. This study used school rosters from Academy schools and data from Chicago Public Schools to link students to teachers. The study compared students taught by Academy teachers to students in the same school who were not taught by Academy trained teachers. The study found that students taught by Academy trained teachers answered a greater percentage of questions correctly than their classmates who were taught by non-Academy trained teachers. This was true for every subset of questions in the math exam, and was particularly pronounced in content areas such as geometrical relationships, data analysis and interpretation, which are stressed in the Academy program.

The advantage to this approach rests in the homogeneity of the populations. Since students in both groups attend the same elementary school and reside in the same communities, they reflect the social milieu of the community. This minimizes the existence of sharp differences between the two populations with respect to income, ethnicity, culture and/or orientation to education. In a sense classroom analyses provide a more controlled example of the *Academy effect,* while at the same time providing for a relatively simple presentation of findings that are easily understood by stakeholders who are unsophisticated with statistics.

The disadvantage to this approach has more to do with the difficulty in obtaining the data necessary to conduct these studies. As noted earlier, school district policies make it very difficult to obtain data that allows one to link students to teachers. In order to do this, the Academy had to obtain physical hard copies of teacher classroom assignments for the period in question. Once these were obtained a long and arduous data cleaning and coding process was necessary. Once completed, the newly obtained data had to be linked to the existing test score database via a third data set containing student classroom assignments. This data set was obtained from Chicago Public Schools (CPS). Hence, the analysis was limited to schools in Chicago District #299 that participated in the Academy program. Further, it was not possible to obtain rosters for all schools of interest. This was largely due to the amount of time that had been allowed to lapse between the applicable roster year and the request to obtain the roster. Thus, not all of the relevant Academy schools were included in the analysis. Moreover, while the students in question may have come from the same community and may reflect the social composition of the community, it is possible the classroom distribution of students was not random among teachers who chose to participate in the Academy program and those who did not. It might also be argued that Academy students did better because the best (or most dedicated) teachers in the school chose to participate in the Academy program. Hence, the findings are a statistical artifact of a natural selection process among the teachers themselves. No pre-program comparisons were made to test for this possibility.

7.4) Regression Studies

Ordinary least squares regression (multiple regression) studies represent the most statistically rigorous assessment of the *Academy effect.* As we noted earlier, these studies used a "value-added" approach to assessing the *Academy effect.*

The regression studies are important because of the strength of their controls. In addition to income and ethnicity, these studies also controlled for initial starting points (pre-program test scores), student mobility, truancy rates, school size, and the percentage of students with limited English proficiency. While there are no assurances that all of the relevant variables were controlled, these studies clearly surpass the paired-comparison approach in the rigor of its methodology and degree of statistical control.

The OLS Regression studies are limited because of the way in which they dealt with the switch from the IGAP to the ISAT that occurred in the 1999-2000 period. The research used a direct translation of student test scores by simply adjusting the IGAP 120 point metric scale to the ISAT 500-point metric. While this conversion was easily accomplished mathematically and allowed for a long-term investigation of the *Academy effect*, there are no real assurances the two tests did not differ in other ways. Further, they are limited by their focus on test scores. This focus lies at the root of the metric conversion issue.

The regression studies are also subject to two criticisms raised earlier. First, their focus is on changes at the school level and thus the findings do not reflect individual growth among students. Second, because not all teachers in a school participate in the Academy program, these studies cannot account for the possibility that the observed changes in school performance are the result of improvement in performance by students taught by non-Academy teachers. Similar regression studies undertaken at the student level do not suffer from these two criticisms. These results of these studies also show moderate to strong "Academy Effects" in 3rd grade mathematics and 7th grade science, but do not show the impact on 4th grade science evidenced in the school level regressions. All of the regression studies are limited because stakeholders untrained in regression analysis have difficulty understanding them.

7.5) Sub-population Comparisons

Like the previously cited studies, this research also has its advantages and disadvantages. Its advantages rest in the strength of its use of student level data. It is based on <u>same student</u> comparisons. It compares students taught by Academy trained Vs non-Academy trained teachers and its comparison of similar groups of students (Males to Males/Females to Females, etc). The analysis is subject to criticism on the grounds that it does not have adequate controls for differences between groups. However, since comparisons were based on the performance of the same students from the same cohort at different points in time, the comparisons involve students of approximately the same age and grade level. The fact that specific controls were not used for income differences is actually testament to the strength of the effect because failure to control for income differences favors non-Academy students. Unlike Academy students who are more likely to come from low-income families (a reflection of the Academy's entrance requirements), non-Academy students represent a broader spectrum of the District #299 population and as such they are more likely to possess the financial resources and exposures needed to excel academically.

Conclusions

Direct measures of the transference of mathematics and science content knowledge to teachers indicates teachers participating in the Academy program in three different Illinois communities (Chicago, East St. Louis and Joliet) posted higher scores on content tests after having completed one year of the Academy program. Multiple indirect measures of the subsequent transfer of mathematics and science content knowledge to students, suggests teachers are able to transfer this knowledge and the skills learned to students in meaningful ways and that students assimilate this knowledge.

A comparison of the percentage of students meeting or exceeding 3rd grade math standards on the ISAT showed schools that participated in the Academy program gaining on their non-Academy counterparts over time. A comparison of student performance on the mathematics subsets of the ISAT showed Academy students posting a higher percentage of correct answers than their non-Academy counterparts. Same school comparisons found students taught by Academy trained teachers out-performed students taught in the same school but by non-Academy trained teachers. Multivariate statistical models showed that when initial starting points and demographic differences between schools are controlled, the Academy's program had a medium to large effect depending on the subject-grade combination tested.

The recorded observations of the Academy's professional developers provide qualitative evidence in support of these conclusions. These observations add a richness to the data and findings that allow one to better understand the nature of the change process, as well as the problems and issues one confronts in implementing inquiry based learning techniques in low-income high-minority schools.

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