A Preliminary Examination of Baltimore Ingenuity Student Outcomes: Classes of 2008 and 2013

Rachel E. Durham

November 2014

BERC wishes to acknowledge the assistance of the following, without whom we could not have completed this research: Steve Farber, Dennis Jutras, David Nelson, Michael Pih, Lawrence Reid, and Laura Szymanski.

The study was completed through the generous support of the Abell Foundation.

Table of Contents

List of Tables

This page intentionally left blank.

A Preliminary Examination of Baltimore Ingenuity Student Outcomes: Classes of 2008 and 2013

Executive Summary

The Ingenuity program was designed to "provide Baltimore's brightest middle school students with a free, highly accelerated, and challenging mathematics and science curriculum" (Ingenuity Project, 2014). It started in 1993 at two middle schools, one on the east side of Baltimore and the second on the west, but as of SY 2014-15 the program is in place in several middle schools and one high school. Students must participate in a competitive application process, and those selected represent some of Baltimore's brightest and most motivated students, a group who some worry is too often ignored in urban school districts. Participants benefit from an extraordinary opportunity for enriched, accelerated math and science course taking and mentorship.

Students served by Ingenuity are less likely to be African American or receive free/reduced price meals than the district in general. The program serves approximately 270 middle school students (approximately 90 students in each grade) and 120 in high school (around 30 in each grade per year). Ingenuity Project is offered at Baltimore Polytechnic Institute (Poly) and in the middle grades at Hamilton, Mt. Royal, and Roland Park K-8 schools.

Research questions for this analysis were developed using a participatory model that included staff from the Ingenuity Project, Baltimore City Schools, the Abell Foundation, and university researchers of BERC. Questions are primarily focused on whether the program has an impact on high school and postsecondary outcomes, as well as student self-efficacy. The analysis features a comparison with a set of similar students who never participated in Ingenuity. It also includes current and former participants' responses to an online survey about their career plans and progress.

The findings show that a cohort of students who participated in the Ingenuity program *during middle school only* out-performed comparable peers in terms of high school academic behaviors (e.g., advanced course and AP exam-taking), and outcomes (e.g., course grades or SAT scores). Students who participated in the *high school component* also showed significantly higher outcomes relative to similar peers who did not participate, and were also more likely than comparable students to have completed a four-year college degree after four years.

According to current Ingenuity students' survey responses, over 95% intend to pursue a four-year degree, and approximately three-fourths are interested a STEM field of study. Likewise, about 95% of former Ingenuity students reported they were enrolled in a four-year degree-granting college, with two-thirds studying for a STEM career. Respondents from both groups most commonly were interested in, or were pursuing studies in biology and/or medicine. Among alumni participating in the survey who are now enrolled in college, virtually all are making expected (or accelerated) progress towards a degree.

There are several cautions that must be made with respect to the study's generalizability. We could not control for *unobserved* characteristics among the Ingenuity students and the comparison groups that represent important differences that may have affected outcomes,

especially parental support for education, socioeconomic background and the intrinsic qualities of the students themselves, such as enthusiasm for mathematics and science.

Most importantly, however, the non-Ingenuity students may not have had the same course-taking opportunities as Ingenuity participants. Students at some middle and high schools had access to more rigorous course options, especially in math and science, which made true comparisons impossible.

As a result, we avoid making any causal statements about the effects of Ingenuity, as students were not randomly assigned to the program but were targeted for participation because of exceptional qualifications.

A Preliminary Examination of Baltimore Ingenuity Student Outcomes: Classes of 2008 and 2013

Rachel E. Durham

Background

The Ingenuity program is intended to "provide Baltimore's brightest middle school students with a free, highly accelerated, and challenging mathematics and science curriculum" (Ingenuity Project, 2014). Started in 1993, two participating middle schools were strategically selected to host Ingenuity based on their location, with one each in east and west Baltimore to ensure equal geographic access. Since that time, the program has expanded to one high school, Baltimore Polytechnic Institute, and is now offered at several middle schools different from the inaugural schools.

Students must first complete a challenging application process to participate in Ingenuity. Selection is based on a review of students' past grades, state assessment scores, daily attendance, and teacher recommendation letters, as well as additional standardized testing. Students' application portfolios are scored, and those with scores in the top percentile ranking among all applicants are invited to participate (percentile cut-points depend upon both demand and available seats for the upcoming school year). Students chosen for this program benefit from an extraordinary opportunity for enriched, accelerated math and science course taking and mentorship. They represent some of Baltimore's brightest and most highly motivated students, a group who some worry is too often ignored in urban school districts.

Ingenuity serves a population of students that is different from the district overall. This is true even within Baltimore Polytechnic Institute (Poly). During SY 2012-13, 58% of students attending Poly received FARM services and 76% were African-American and/or Hispanic,[1] whereas among Ingenuity graduates of 2013, 41% received FARM and 50% were ethnic minority. This difference suggests that the opportunity to benefit from Ingenuity is concentrated among students who are, on average, more affluent and less ethnically diverse than their school peers.

Moreover, Ingenuity serves a relatively small share of Baltimore's students. Around 90 students in each of sixth, seventh, and eighth grade participate in the Ingenuity middle grades program (i.e., approximately 270 per school year, or slightly less than 2% of all City Schools 6^{th}-8^{th} graders). Currently three schools serving grades 6 through 8 offer Ingenuity – Hamilton Elementary/Middle, Roland Park Elementary/Middle, and Mt. Royal Elementary/Middle School. Typically, only about one-third of these are accepted to continue into the high school Ingenuity program at Poly. As a result, each new cohort of ninth grade Ingenuity participants includes around 30 students. Appendix A provides a timeline showing the opening and closing dates of each school's Ingenuity program.

[1] Figures from Poly for 2012-13 were obtained from mdreportcard.org [retrieved May 25, 2014].

Methodology

This section will review the research questions, and describe the data and procedures used to respond to each question.

Research Questions

This report will respond to the following research questions, using de-identified administrative data records provided by the Office of Achievement and Accountability at City Schools:

1) Relative to a comparable set of peers, did middle grades-only participants:
   - Earn more advanced math and science course credits?
   - Achieve higher grades in math and science courses, as well as overall?
   - Take more Advanced Placement (AP) courses, a greater number of AP exams, and did they receive higher scores on the exams?
   - Achieve higher SAT and PSAT scores?
   - Graduate on time at a higher rate?

2) Relative to a comparable set of peers, did high school graduates of Ingenuity:
   - Earn more advanced math and science course credits?
   - Achieve higher grades in math and science courses, as well as overall?
   - Take more Advanced Placement (AP) courses, take a greater number of AP exams, and did they receive higher scores on the exams?
   - Achieve higher SAT and PSAT scores?
   - Enroll more often at postsecondary institutions, and at more selective institutions (per Barron's Profiles of American Colleges, 2009)?
   - Complete more four-year degrees?

3) Do current and former Ingenuity students report strong efficacy in STEM, and attachment to STEM-related career goals?

Cohort Analysis

Three cohorts of students were included in the quantitative analysis of high school outcomes:

- Those who participated in Ingenuity only during grades 6-8 from 2006-07 through 2008-09 and did not continue into the high school Ingenuity program, but whose on-time graduation year was 2013,

- Those who participated in Ingenuity at Baltimore Polytechnic Institute in 9^{th}-12^{th} grades beginning in 2004-05 and graduating in 2007-08,

- Those who participated in Ingenuity in Baltimore Polytechnic Institute in 9^{th}-12^{th} grades beginning in 2009-10 and graduating in 2012-13.

Middle Grades-Only Participants. The focal group for this portion of the analysis included 49 students who participated in Ingenuity during grades 6 - 8 in 2006-07 through 2008-09, respectively. Comparison students: a) were in fifth grade in 2005-06, b) never participated in Ingenuity during grades 6 through 12, and c) attended at least one year of high school in Baltimore City so an outcome status could be determined. Both comparison and Ingenuity middle grades students would have been on-time graduates in 2012-13.

High School Participants. In 2012-13 there were 28 Ingenuity graduates, and in 2007-08 there were 24. For each Ingenuity cohort, a set of 17 comparison students were identified. The comparison students: a) started ninth grade at Poly in the same year as the Ingenuity cohort, b) had never participated in Ingenuity themselves, and c) remained in a City Schools high school through graduation. Virtually all Ingenuity and comparison graduates attended and graduated from Poly.

Identical matching procedures were used to identify comparison students for both the middle and high school outcome analyses. We matched students according to gender, ethnicity, FARM status, LEP status, special education service receipt, prior attendance rate, and middle grades state assessment scores in math and reading. (More details about Ingenuity students' and the comparison groups' characteristics, as well as the matching procedure can be found in Appendices B and C, respectively.)

Surveys

To answer the last research question concerning Ingenuity participants' self-efficacy and attachment to science/technology/engineering/math (STEM) fields of study, we solicited responses to two online surveys: one targeted to current high school Ingenuity participants who were in 10^{th}, 11^{th}, or 12^{th} grade during SY 2013-14, and a second for former Ingenuity students who, as of spring 2014, were one, two, or three years past high school graduation. Participants for the current student survey data collection effort were recruited by Ingenuity staff working in the high school with current program students, and all Ingenuity students in grades 10 through 12 were given the option to participate. For the alumni survey data collection effort, participants were recruited through email inquiries from Ingenuity staff, who have attempted to maintain contact information for their graduates. However, given that former students who continue to be in contact with Ingenuity staff may have a more favorable perception of the program, the respondents who participated in the survey (as well as those for whom email addresses were even valid and available) may represent a select population of Ingenuity alumni.

The majority of the questions used in the survey were taken from the Pre-College and Current Study versions of the Assessing Women and Men in Engineering Annual Self-Efficacy Surveys (2006), which were developed under a National Science Foundation grant to examine students' trajectories through STEM courses of study. A second source for the survey questions pertaining to perceptions of self-efficacy was the Cooperative Institutional Research Program's (CIRP) Freshman Survey (2014) (used with permission). Using previously-developed survey items is advantageous, since their relationship to underlying constructs of self-efficacy and attachment has already been determined to be valid and reliable.

The survey response rate was approximately 70% for current Ingenuity students and 56% for Ingenuity alumni.[2] Questions asked about basic demographics, their plans for STEM-related careers, and for ratings of agreement with items gauging self-confidence, self-efficacy, and their expectations around a career in STEM.

[2] No non-Ingenuity students were surveyed for comparison purposes, due to the infeasibility of identifying appropriate controls *ex ante* of knowing the characteristics of survey respondents. Further, all survey participation was anonymous and no personally identifying information was collected.

Findings

The next sections will respond to each research question beginning with the analysis of outcomes for the middle school-only participants, followed by an outcome analysis for the high school Ingenuity program participants, and finally we present the results of the surveys administered to current Ingenuity participants and recent alumni.

Middle Grades-Only Participants' Outcomes

Earning Credits in Advanced Math and Science. To measure differences for middle grades-only participants in advanced course taking, we first identified City Schools courses that are considered to be "advanced" with guidance from the Office of Gifted and Advanced Learning. For math, such courses offer credits beyond those required for Algebra I/Data Analysis, Geometry and Algebra II, and include AP Calculus AB/BC, AP Statistics, and Honors Trigonometry, among others. For science, advanced courses include those beyond Biology I or Environmental Science I, Chemistry I, and Physics I. Examples of these courses included Microbiology I, AP Biology, AP Chemistry, AP Physics, Thermodynamics, Honors Research Practicum, etc.

Concerning the number of "advanced" credits subsequently earned in high school math and science, we found that students who had been in Ingenuity only in grades 6 through 8 earned, on average, 3.5 credits in math compared to 2.5 among comparison students (see Table 1). For advanced science credits, Ingenuity students earned 3.9, as compared to 2.7 among their peers. Both differences were statistically significant.

Table 1
Mean Credits Earned in Advanced Mathematics and Science during High School, for Ingenuity Middle Grades Cohort and Comparison

	Ingenuity – Middle Grades Only	Comparison – No Ingenuity
Adv. Math	3.5**	2.5
Adv. Science	3.9*	2.7

**p<.01 *p<.05

Grades in Math and Science. When we compared performance in advanced as well as regular math and science high school courses, students who had been Ingenuity participants earned higher grades, and all differences were statistically significant except for advanced math course performance. Ingenuity students also had significantly higher weighted GPAs at the end of high school than comparable students, with an average 3.0 compared to 2.5 (see Table 2). It should be noted that weighted GPA reflects a weighting factor of 1.2 for any AP course and a factor of 1.1 for an Honors course; thus if the middle school Ingenuity participants had more opportunities to take AP or honors courses in high school than students in the comparison group, then average GPA would yield a greater difference in performance than numerical course grades.

Table 2
High School Course Performance, for Ingenuity Middle Grades Cohort and Comparison

	Ingenuity – Middle Grades Only	Comparison – No Ingenuity
Advanced Math	80.3	76.6
Advanced Science	81.6**	75.1
All Math	81.3*	77.1
All Science	81.9**	76.5
Weighted Final GPA	3.0**	2.5

**p<.01 *p<.05

AP Courses, Exams and Scores. As seen in Table 3, Ingenuity students earned significantly more Advanced Placement credits in high school than comparison students (9.3 versus 5.8), and they took more AP exams and received higher AP scores, although neither difference was significant.

Table 3
Advanced Placement Credits, Examinations and Average Scores, for Ingenuity Middle Grades Cohort and Comparison

	Ingenuity – Middle Grades Only	Comparison – No Ingenuity
Credits Earned (N)	9.3 †	5.8
Exams Taken (N)	2.0	1.4
Average AP Exam Score	2.7	2.2

**p<.01 *p<.05 †p<.10

SAT and Preliminary SAT (PSAT) Table 4 contains average PSATs and SATs that represent a student's *highest* score reported for a subject, from any testing administration. This distinction is important for students who took assessments two or more times, as their highest math score might have been achieved during a testing session that did not produce their highest verbal or writing score, and further, their highest score may not be their most recent. Then, the highest combined score (sum of verbal, math and writing sub-scores) is the highest combined score they achieved during any single testing session.

With respect to the average highest PSAT and SAT scores they achieved, we found that middle grades-only Ingenuity students later achieved significantly higher scores than comparison students, across all subject areas and for both exams.

Table 4
Mean SAT and PSAT performance, for Ingenuity Middle Grades Cohort and Comparison

	Ingenuity – Middle Grades Only	Comparison – No Ingenuity
PSAT Performance		
Verbal	56**	48
Mathematics	55**	48
Writing	54**	47
Percent who took PSAT	98%	96%
SAT Performance		
Verbal	574**	498
Mathematics	564**	487
Writing	559**	484
Combined	1679**	1451
Percent who took SAT	98%	90%

**p<.01 *p<.05

On-Time Graduation. Finally, nearly all middle grades-only Ingenuity students graduated on time in the spring of 2013, though one was in 12th grade but did not graduate that year. Among the comparison group, 90% graduated on time, a handful of students were in 12th grade but did not graduate that year, one student had fallen behind in grade, and one student had dropped out of school (see Table 5).

Table 5
High School Completion Outcomes, for Ingenuity Middle Grades Cohort and Comparison

	Ingenuity – Middle Grades Only	Comparison – No Ingenuity
2012-13 Graduation Status		
% Graduated	98.0 †	89.8
% Not Graduate, but in 12th grade	2.0	6.1
% 11th grade	0.0	2.0
% Dropped Out	0.0	2.0

**p<.01 *p<.05 †p<.10

High School Participants' Outcomes

These analyses include students who participated only during high school or were in the program during both middle school and high school. Too few students participated in either the middle and high school or high school-only program for two separate analyses, so both groups were considered together against similar comparison peers.

Taking Advanced Courses in Science and Math. Table 6 presents the mean number of credits earned by high school Ingenuity participants and their comparison peers in advanced math and science courses. In all instances, the mean difference was statistically significant with Ingenuity students earning more advanced credits than comparable peers. An interesting finding is that relative to 2007-08 Ingenuity graduates, the more recent 2012-13 graduates had earned more credits in both math and science.

Table 6
Mean Credits Earned in Advanced Mathematics and Science, for Ingenuity High School Cohorts and Comparison

	2007-08		2012-13	
	Ingenuity	Comparison	Ingenuity	Comparison
Adv. Math	2.9**	2.2	4.1**	2.6
Adv. Science	4.7*	3.5	7.2**	2.5

**p<.01 *p<.05

Grades in Math and Science. Final weighted GPA comparisons were possible for 2013 graduates, but were not available for the 2008 graduates due to recent changes in district grading policy. Conversations with district research personnel suggested that replicating the current procedure for the older cohort would be difficult if not impossible, since course offerings, descriptions, and weighting policies have changed since 2008. Thus, for the 2008 graduates, we only compare final numerical grades. This limitation also suggests that comparisons of the courses of study between Ingenuity graduates in 2008 and 2013 should be made with caution.

Table 7
High School Course Performance, for Ingenuity High School Cohorts and Comparisons

	2007-08		2012-13	
Courses	Ingenuity	Comparison	Ingenuity	Comparison
Advanced Math	87.3**	78.1	85.2*	79.1
Advanced Science	90.2**	83.5	86.3**	76.1
All Math	88.1**	81.0	86.2	81.2
All Science	89.0**	83.3	85.8**	77.2
wGPA, all Courses	-	-	3.5**	2.7

**p<.01 *p<.05

Table 7 shows that for both comparisons of advanced math and science courses, high school Ingenuity students earned significantly higher marks than comparable students. Then, concerning *all* math and science course taking (which includes advanced as well as required courses) we

found that among the 2008 graduates, Ingenuity students earned significantly higher grades. For the 2013 graduates, Ingenuity students received significantly higher marks in science, but not math, as compared to similar peers at Poly. However, when weighted GPA for all courses taken in high school was considered, the average GPA of Ingenuity participants was significantly higher at 3.5, compared to 2.7 for their peers. Though as seen in Table 6, the 2013 Ingenuity graduates had earned more advanced credits, and many advanced courses have AP and honors designations, which are weighted more heavily in GPA calculations.

AP Course Taking in Science and Math. Ingenuity graduates in both cohorts earned more Advanced Placement credits and took more than twice as many AP exams as comparable students. As seen in Table 8, performance on AP exams varied by cohort.

Table 8
Advanced Placement Credits, Examinations and Average Scores, for Ingenuity High School Cohorts and Comparison

	2007-08		2012-13	
	Ingenuity	Comparison	Ingenuity	Comparison
N, AP Credits Earned	5.4**	2.1	7.5**	2.0
N, AP Exams Taken	6.4**	2.3	7.3**	2.0
Average AP Exam Score	3.3*	2.3	3.0	3.1

**p<.01 *p<.05

These differences between both cohorts and their comparison peers with respect to the number of AP exams taken may also indicate disparities in course-taking opportunities for Ingenuity students at Poly, relative to non-Ingenuity students.

Ingenuity graduates from the Class of 2008 scored significantly higher on AP exams than their comparison peers, while those from the later cohort, on average, earned scores that were statistically similar to those of their peers, though Ingenuity students took over twice as many exams.

SAT and Preliminary SAT (PSAT). Table 9 contains average PSATs and SATs representing a student's *highest* score reported for a subject, from any testing administration. (As before, their highest score may not be their most recent.) Unfortunately, PSAT scores for the years that the 2008 graduates would have been tested (i.e., fall 2006 and 2007) were not available.

In each instance considered, Ingenuity students achieved significantly higher PSAT and SAT scores than comparable students. Further, Ingenuity students who graduated in 2013 were more likely to have taken the SAT than comparison students. Among the 2013 graduates, for whom PSAT comparisons can be generated, it appears that Ingenuity students showed more improvement than their peers between taking the PSAT and sitting for the SAT. Calculating the predicted SAT score from a PSAT score is achieved by multiplying the PSAT score by 10, so for instance, among the comparison graduates of 2013, the average PSAT verbal score, 52, was close to the SAT verbal scores they eventually earned, 533. But among Ingenuity participants, their average SAT verbal score of 619 was much higher than the predicted 580 from their average PSAT verbal score of 58.

Table 9
Mean SAT and PSAT performance, for Ingenuity High School Cohorts and Comparison

	2007-08		2012-13	
	Ingenuity	Comparison	Ingenuity	Comparison
SAT				
Verbal	647**	581	619**	533
Mathematics	693*	636	684**	583
Writing	650*	592	602**	523
Combined	1971**	1791	1887**	1611
Percent who took SAT	100%	92%	100% †	89%
PSAT				
Verbal	-	-	58*	52
Mathematics	-	-	65**	55
Writing	-	-	56*	49
Combined	-	-	179**	155
Percent who took PSAT	-	-	100%	100%

**p<.01 *p<.05 †p<.10

College Enrollment and Institutional Selectivity (per Barron's Profiles of American Colleges, 2013). At this time, postsecondary enrollment data are available only for the 2008 graduates. National Student Clearinghouse (NSC) data report enrollment dates and the institutions where students enrolled, and the most recent City Schools' NSC data are capable of providing this information for the graduating classes of 2005 through 2012. While we believe any postsecondary experience is noteworthy, for the current research question we elected to consider enrollments that occurred during the fall immediately following high school graduation. This approach allows us to consider student differences demarcated at a single point in time, and furthermore, enrollments following on the heels of graduation signal a commitment to the postsecondary study path whereas delayed enrollment may suggest that students are considering career options that do not require a college degree.

Table 10
Fall Enrollments at Postsecondary Institutions among the Class of 2008,
Ingenuity High School Cohort and Comparison

	Ingenuity	Comparison
Fall Enrolled	83.3%	91.7%
Two-Year College	0.0%	6.3%
Four-Year College	100.0%	93.8%
Selectivity:		
Very Selective	55.0%	29.4%
Selective	30.0%	23.5%
Somewhat Selective	15.0%	23.5%
Not Selective	0.0%	23.5%

Note. No significant differences on any measure. Source: NSC.

Table 10 presents a comparison of the percentage of Ingenuity graduates and their peers who enrolled at a college or university in the fall after graduation. Although a higher share of comparison than Ingenuity students enrolled the following fall,[3] this difference was not statistically significant. Further, all of the fall enrollments by Ingenuity participants were in four-year institutions, and the schools they attended had higher selectivity ratings, per Barron's profiles (Barrons, 2013). But again, none of these differences were significant.

Earning College Degrees. Data from NSC also provides information on degree completion. The most current NSC data represented a time window that would have allowed the 2008 graduates four years plus one fall semester to complete a bachelor's degree. As shown in Table 11, a higher share of Ingenuity participants had completed a degree during this time frame. This is true for those who enrolled in the fall following high school, as well as when considering enrollments at any time after high school.

While comparisons of degree completion were only marginally statistically significant, the differences are certainly *substantively* significant given degree completions were on the order of one and a half times greater among Ingenuity graduates.

Table 11
Postsecondary Degree Completion among the Class of 2008,
Ingenuity High School Cohort and Comparison

	Ingenuity (N=24)	Comparison (N=17)
All Students:	62.5%	41.7%
Among only Fall-Enrolled:	75.0%	45.5%

Both differences were marginally significant (p<.08). Source: NSC.

Efficacy in STEM and Attachment to STEM-related Career Goals

To gauge current and former Ingenuity students' self-perceptions around STEM and their career plans and progress, we solicited responses to two online surveys: one targeted to high school Ingenuity participants who were in 10th, 11th, or 12th grade during SY 2013-14, and a second for Ingenuity alumni who, as of spring 2014, were one, two, or three years past high school graduation. As noted previously, survey response rates were around 70% for current Ingenuity students and 56% for Ingenuity alumni.

As shown in Table 12, the high school survey respondents were 51% male, half were 10th graders, one-third were in 12th grade, while around 41% were white and 30% African-American. A little more than half reported that at least one of their parents had an advanced/graduate college degree.

[3] In analyses not shown, it was found that if college enrollments at *any* time were considered, Ingenuity graduates enrolled at a higher rate than their comparison peers, though this difference was not statistically significant.

Table 12
Description of Current Ingenuity Students Completing the Survey

Grade Levels:	Percentage
10th	49.4
11th	18.8
12th	31.8
Male	51.0
Female	49.0
White	40.7
African-American	30.2
Hispanic	3.5
Asian	5.8
More than one	11.6
No Answer	8.1
Parents' Education Level:	
High School or less	10.5
Some college	11.6
College Graduate	19.8
Advanced Degree	51.2
No Answer	7.0
Number of Respondents Who Finished Survey	83

When asked about post-high school plans, about three-fourths of current high school Ingenuity students reported that they intend to go to college to prepare for a career in STEM. Most respondents were "fairly sure" or "very sure" about their career intentions, and nearly all reported a specific field of study in which they were most interested.

Table 13
Career Plans of Current High School Ingenuity Students

	Percentage
Planning for a STEM Career	77.6
No plans for a STEM Career	22.4
How confident are you about your plans?	
Not very confident; it's likely to change	4.7
50% chance I'll change	9.4
Fairly confident	52.9
Very confident	32.9

Table 13
Career Plans of Current High School Ingenuity Students

	Percentage
What Field(s) of study are you interested in pursuing?	
Medicine/Biology	32.6
Physical/Mech/Elec Engineering/Physics	25.0
Social Science/Statistics	12.0
Chemistry/Chemical Engineering	9.8
Computer Science/Software Design	6.5
Environmental Science/Geology	4.3
Astronomy/Astrophysics	4.3
Forensic Science	3.3
Humanities/Fine Arts	2.2
What sources of information have you used to make your plan regarding career and college?	
Parent(s)	77.9
Ingenuity peers	54.7
Campus visits	53.5
Ingenuity teachers	48.8
High school activities	48.8
Counselors	48.8
Other college activity(s)	45.3
Other family members	34.9
Other high school teachers	34.9
Employer(s)	8.1

The range of fields in which students reported wanting to pursue a degree are presented in Table 13. Students most frequently reported interest in medicine or another field within biology, followed by physics and engineering. Specifically, students gave responses such as, biotechnology, biomedical engineering, biochemistry, neurology, zoology, neonatology, molecular biology, genetics, or simply "medicine" or "biology." After biological fields, there was common interest in electrical engineering, mechanical engineering, civil engineering, or just "physics." The next most popular career interests were in the social sciences (sociology, economics, psychology, public health), followed by chemistry and chemical engineering.

Many students listed more than one interest, though most students seem to have narrowed their interest to a single field of science but were still considering more than one particular focus within that field.

Most students reported more than one source of information about going to college, with about three-fourths reporting their parents, and one-third other family members. More than half reported that they got information from college visits, their peers in the Ingenuity program, and nearly half from Ingenuity teachers, college activities, high school activities, or counselors (see Table 14).

When asked how hard they believed they work to get good grades in their high school classes, and how hard they expected they will need to work in college, 43% reported that they "work hard" in their high school courses while about one-third said they just "work some, but not too hard." A handful of students said it was "easy", or "easy with a few exceptions." However, 63% reported they expect that they will need to work harder when they are in college. Further, most expect that they will adjust well to college life, and over 80% were confident in their ability to complete a college degree (see Table 14).

Table 14
Current Ingenuity High School Students' Expectations about College

	Percentage
How easy is it to get the grades you want in high school classes?	
It's easy	3.5
With a few exceptions it's easy	14.0
I work some, but not too hard	36.0
I have to work hard	43.0
I don't work hard; don't care about grades	3.5
How hard do you think you'll have to work in college?	
I'll have to work less	8.1
I'll have to work about the same	29.1
I'll have to work harder	62.8
To what extent do you agree that you'll adjust well to college?	
Strongly Disagree	0.0
Disagree	1.2
Slightly Disagree	0.0
Neither agree nor disagree	4.7
Slightly Agree	7.1
Agree	41.2
Strongly Agree	45.9
How sure are you that you'll complete a college degree?	
Not sure, highly likely I won't finish	1.2%
About 50% sure	2.3%
Fairly confident	16.3%
Very confident	80.2%

Next, students were asked about their feelings of belonging within the fields of STEM, their expectations for success in a STEM-related career, their expectations concerning personal satisfaction if they pursue a career in STEM, self-efficacy with respect to STEM, as well as for self-assessments of their knowledge, creative thinking skills, and soft skills (see Appendix C for specific questions and constructs).

As seen in Table 15, most current high school Ingenuity participants reported agreement ("agree" or "strongly agree") with statements expressing an expectation for success and personal

satisfaction in a STEM career. They also expressed a high degree of self-efficacy around STEM course performance and their ability to achieve balance between professional and personal lives.

On average self-assessments of knowledge and creative thinking were high, but interestingly, girls rated themselves significantly lower than boys on confidence in their ability to think creatively. We also noted that those who declared an intention to pursue a career in STEM were significantly more likely to agree with statements relating to feelings of belongingness within STEM, expectations for satisfaction and success with a STEM career, and STEM-related self-efficacy.

Table 15
Current Ingenuity High School Students' Mean Self-Ratings on Efficacy, Confidence, Expectations and Belongingness around STEM

	Feeling of Belonging within STEM Field	Expectations for Personal Satisfaction with a Career in STEM	Expecta-tions for Successful Career in STEM	STEM Self-Efficacy	Self-Rating of Knowledge Generally and in your Field	Self-Rating of Ability to think Creatively	Self-Rating of Soft Skills
Grade							
10th	5.3	5.4	6.0	6.1	4.2	4.3	3.0
11th	5.2	5.4	6.4	6.3	3.9	4.3	2.8
12th	5.5	5.4	6.0	5.9	4.1	4.3	2.8
Gender							
Male	5.3	5.5	6.1	6.2	4.2	4.5	2.9
Female	5.3	5.3	6.0	6.0	4.1	4.1**	2.9
STEM Career							
Have Plan	5.6	5.8	6.3	6.3	4.1	4.4	2.9
No Plan	4.4**	3.9**	5.2**	5.2**	4.1	4.2	2.9
All	5.3	5.4	6.1	6.1	4.1	4.3	3.0

**p<.01

Note. For the first 4 constructs, answers could range from 1=Strongly Disagree to 7=Strongly Agree. For last 3 constructs, answers could range from 1=Major Weakness to 5=Major Strength.

Ingenuity Alumni. About one-third of the Ingenuity alumni who completed the survey graduated City Schools in 2011, 20% graduated in 2012, and 45% in 2013. The distribution of alumni by their parents' highest educational level and race/ethnicity was similar to that for current Ingenuity students, with around 40% white and 36% African American and around 48% having a parent with an advanced degree. Slightly more male than female alumni participated in the survey.

Table 16
Description of Ingenuity Alumni Completing the Survey

	Percentage
Graduation year:	
2011	34.1
2012	20.5
2013	45.5
Male	59.1
Female	40.9
White	40.9
African-American	36.4
Hispanic	2.3
Asian	11.4
More than one	6.8
No Answer	2.3
Parents' Education Level:	
High School or less	18.2
Some college	15.9
College Graduate	13.6
Advanced Degree	47.7
No Answer	4.5
Number of Respondents Who Finished Survey	44

When we asked about their current status and career plans, 42 of the 44 Ingenuity alumni reported that they were enrolled in a four-year college, one reported being enrolled in a two-year college, and one reported that s/he was neither in college nor working. About two-thirds reported that they were working towards a four-year degree within a STEM field, while one-third were studying non-STEM subjects. In either case, more than 90% of respondents were fairly or very confident about their plans.

Alumni reported their progress toward a degree, and we compared this to their year of high school graduation (see Table 17). All of the alumni enrolled in college were in a stage of their studies that corresponds with expected progress or were even further along in credit accrual.

Table 17
Spring 2014 Matriculation Status (%) of Ingenuity Alumni, by Year of High School Graduation

Year Graduated (N):	College Freshman	College Sophomore	College Junior	College Senior
2011 (14)	0	0	60.0	40.0
2012 (9)	0	77.8	11.1	11.1
2013 (20)	55.0	45.0	0	0

Alumni reported a more narrow range of fields of study than those reported by current high school Ingenuity students (which would be expected for those already accruing credits in a particular field). But as with current Ingenuity students, most reported medicine or another area of biology. The second most frequently reported field of study was physics or engineering, followed by computer science or software development (see Table 18).

Most alumni reported that they felt they had had enough information about career options during their high school years to make an informed decision about a college major (not presented in tables), with 68% agreeing or strongly agreeing; however, about one-fourth of alumni disagreed that they'd had enough information about career choices when they made a decision concerning where to attend college and what their major would be.

When asked to imagine themselves in 20 years and the sort of organization in which they would want to be working, about one-fifth of alumni reported working in a non-academic research organization, nearly one-fifth in an academic environment, and almost one-sixth pictured themselves starting their own enterprise. About one-third reported *other* and among these, one reported 'financial analyst,' one stated 'working in a church,' another said 'US Navy,' and one pictured himself working for the U.S. government, while a handful reported that they imagined themselves as some type of clinical medical provider. Interestingly, none of the former Ingenuity students said they expected to be a school teacher, and a handful reported that they didn't yet know in what arena they would be working.

Table 18
Percent of Ingenuity Alumni by Reported Career Plans

	Percentage
Preparing for a Career in STEM	65.9
No plans for Career in STEM	34.1
How Confident are you about your plans?	
Not very confident; it's likely to change	4.5
50% chance I'll change	4.5
Fairly confident	59.1
Very confident	31.8
What Field(s) of Study are you pursuing?	
Medicine/Biology	45.5
Physical/Mech/Elec Engineering	21.2
Computer Science/Software Design	15.2
Social Science/Statistics	9.1
Environmental Science/Geology	6.1
Astronomy/Astrophysics	3.0
Forensic Science	-
Chemistry/Chemical Engineering	-
Humanities/Fine Arts	-

Table 18
Percent of Ingenuity Alumni by Reported Career Plans

	Percentage
In 20 years, in what arena do you expect you'll be working?	
An academic environment, like a professor	6.8
An academic environment, mostly applied research	11.4
Private enterprise that I build myself or with a team	15.9
A non-academic organization where I am paid to do research or development	20.5
Teaching in a public or private school	0.0
I don't know yet	15.9
None of the above; something different	29.5

Measures of efficacy, attachment to STEM and other competencies, showed no significant differences between male and female respondents, or according to the stage of their college studies (results not shown). Not surprisingly, alumni who reported they were preparing for a career in STEM had significantly higher scores than those who reported they were *not* pursuing STEM, on both their expectations for a personally rewarding career in STEM, as well as STEM-related career success. This comparison along with average ratings across all respondents are reported in Table 19 below.

Table 19
Mean Self-Ratings on Efficacy, Confidence, Expectations and Belongingness around STEM for Ingenuity Alumni

Plans	Feelings of Belonging within STEM Field	Expectations for Personal Satisfaction with a Career in STEM	Expectations for Successful Career in STEM	STEM Self-Efficacy	Self-Rating of Knowledge Generally and in your Field	Self-Rating of Ability to think Creatively	Self-Rating of Soft Skills
STEM Career	5.6	5.9	6.3	6.3	4.3	3.3	4.0
No plans	5.0	4.9**	5.6*	5.8	4.1	3.5	3.8
All	5.4	5.6	6.1	6.2	4.2	3.3	3.9

**p<.01 *p<.05

Note. For the first 4 constructs, answers could range from 1=Strongly Disagree to 7=Strongly Agree. For last 3 constructs, answers could range from 1=Major Weakness to 5=Major Strength.

Discussion and Conclusions

This report examined whether Ingenuity students outperform similar peers with respect to high school and postsecondary outcomes. Analyses focused on two groups: students who participated in only the middle school program and those who participated in either the high school or the middle and high school components of Ingenuity. Outcomes included rigor and performance in high school, college preparation, enrollment in college, and degree completion. In addition, we surveyed current and former Ingenuity participants about their attachment to STEM fields of study and work.

The Ingenuity program serves a small number of students annually, about 90 students each in 6th, 7th and 8th grade, representing less than 2% of students in those grades across the district. In high school, about 30 students are served in each grade, representing less than 0.5% of high school students in the district.

The analysis of Ingenuity student outcomes revealed that middle school-only participants earned more advanced math and science credits, more AP credits, achieved higher GPAs, higher PSAT and SAT scores, and were more likely to graduate on time from high school, as compared to students who were never in Ingenuity. Notably, 94% of those who had participated in Ingenuity during the middle grades were enrolled in the entrance criteria schools of Poly, Dunbar, City College, Baltimore School for the Arts, or Western High School, whereas only 71% of the comparison group attended these 5 schools. This difference suggests the potential for inequities in the opportunities students had for taking advanced math and science courses, AP courses, and other extracurricular activities that may have increased their engagement with school and driven their high school outcomes, as program and course offerings across high schools in Baltimore vary tremendously.

Another related caveat is that while some of the students captured in the comparison group for the middle grades-only portion of the analysis were attending the same middle schools as the Ingenuity participants, 65% attended different middle schools, and thus may have experienced highly *in*comparable levels of academic rigor to prepare them for high school.[4]

High school Ingenuity participants from both the Class of 2008 and 2013 graduating cohorts outperformed comparable students in terms of the number of challenging courses for which they earned credit, the number of AP exams they took, their scores on AP tests and SAT tests, as well as the grades earned in their high school courses. While Ingenuity graduates of 2008 enrolled the following fall in postsecondary institutions at around the same rate as comparable peers, they had finished four-year degrees at nearly twice the rate during the four and a half years since graduation. However, these results should be interpreted with caution, since the Ingenuity students likely had different middle school experiences than those in the comparison groups, which may have strongly affected their later outcomes. In fact, four-fifths of the 2012-13 Ingenuity graduates at Poly had attended either Roland Park or Mt. Royal in middle school (among those enrolled in City Schools in 8th grade), whereas their comparable peers were distributed across 10 other different middle schools.

[4] We explored limiting the potential comparison group to students enrolled at the two participating Ingenuity middle schools only, but given the scope of the program at these schools, too few non-Ingenuity students remained for this approach to be feasible.

Another limitation to these analyses is that a comparison group identified according to several demographic characteristics and performance on a single state assessment does not necessarily constitute a comparable group with respect to other unobserved characteristics, especially intrinsic academic motivation, interest in math and science, and socioeconomic advantage. These unobserved qualities also affect performance and may account for differences in outcomes observed between Ingenuity and comparison students.

Identifying appropriate comparison students within Baltimore, especially for rising 9th graders chosen to participate in Ingenuity as high school students, was extremely challenging. This is evidenced by the fact that only 17 comparable students could be identified for either graduating cohort. This indicates that Ingenuity's selection process successfully achieves its goal of enlisting the most academically equipped students into its program (at least in terms of standardized testing skills, which is a large part of the selection process). Very often, Ingenuity students' average MSA or Terra Nova scale scores were higher than the individual scores of many "advanced" students who were not Ingenuity participants.

In the survey component, the majority of current Ingenuity students and recent alumni reported they have plans for (or are studying towards) a career within a STEM field, most often medicine or engineering. Around 95% of the alumni reported they were enrolled in a four-year degree-granting college or university, and over 95% of current Ingenuity students reported intentions to pursue a four-year degree. The vast majority of both groups reported a high degree of self-efficacy and feelings of belonging within STEM, and strong expectations for successful and personally rewarding STEM careers, although female current participants rated themselves somewhat lower than males on their ability to think creatively.

While the response rate for Ingenuity alumni was lower than desired for making firm statements about this group, two-thirds of those who completed the survey remain strongly attached to goals involving math and science. Moreover, most of the alumni respondents have made notable progress toward these goals through their postsecondary studies.

At the time of this writing, City Schools is developing a district-wide portfolio of gifted and advanced learning programs, within which the Ingenuity Project is envisioned as an important but small part of a new, more comprehensive set of offerings. The findings above point to several related implications:

- Systemic, district-wide opportunities for advanced learning among elementary-aged students are needed to nurture the gifts and talents of the youngest served by City Schools. A program to identify students with special interests and abilities early on can increase student and family engagement with schooling for years to come.

- While it is notable that the Ingenuity middle-grades program is offered at three schools in geographically and demographically diverse sections of Baltimore, greater equity in access to advanced learning options for the middle grades is needed. In particular, Algebra I is a gateway course to many advanced math course taking opportunities in high school, and accessing these is key to students' subsequent postsecondary options. City Schools should consider the feasibility of offering Algebra I at all schools serving 8th graders.

- Students at all of City Schools' high schools should have opportunities to earn credits in AP and honors courses. Expanding such options across the district would better enable its students to submit competitive applications to colleges. College applicants are adjudicated according to their exposure to rigorous courses, as well as GPA, which can be strongly impacted by performance in advanced coursework.

References

Assessing Women and Men in Engineering [AWE]. (2006). *Annual Self-Efficacy Surveys.* Versions: Pre-College and Current Study. [Accessed on December 17, 2013 from http://www.engr.psu.edu/awe/].

Barron's Educational Series, Inc. (2013). *Profiles of American colleges, 30th edition.* Hauppauge, NY: Author.

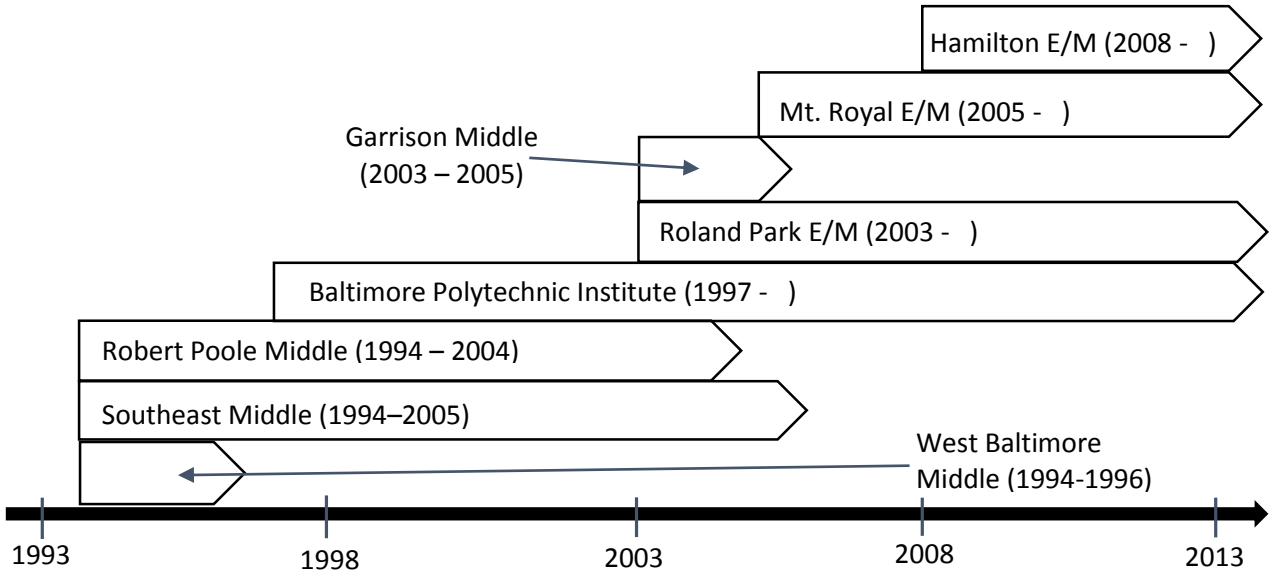
Higher Education Research Institute. (2014). *Cooperative Institutional Research Program (CIRP) Freshman Survey.* [Accessed on December 12, 2013 from http://www.heri.ucla.edu/cirpoverview.php] (Used with Permission).

Ho, D.E., K. Imai, G. King, and E.A. Stuart. (2007). "Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference." *Political Analysis*, 15(3):199-236.

Ingenuity Project (2014) [Accessed on September 10, 2014 from http://www.ingenuityproject.org/program-overview/.

Rosenbaum, P.R. and D.B. Rubin. (1983). "The Central Role of the Propensity Score in Observational Studies for Causal Effects." *Biometrika*, 70(1):41-55.

Appendix A
Timeline of Schools' Participation in the Ingenuity Program



Appendix B
Matching Results for Ingenuity and Comparison students

Middle Grades-Only Participants. The focal group for this portion of the analysis included 49 students who participated in Ingenuity during grades 6 - 8 in 2006-07 through 2008-09, respectively.[5] Identifying a suitable set of students to serve as a comparison group was an initial step. To do so, we first selected into the potential comparison pool students who: a) were in fifth grade in 2005-06, b) never participated in Ingenuity during grades 6 through 12, and c) attended high school in Baltimore City so that an outcome status could be determined. Both comparison and Ingenuity middle grades students would have been on-time graduates in 2012-13.[6]

Once potential matches were defined, a logit matching procedure[7] was estimated. Essentially, the probability of being an Ingenuity participant was regressed against the student variables: ethnicity, gender, 5th grade FARM services, special education services, LEP status, 5th grade attendance rate, and 5th grade MSA scores in reading and math. From this estimation, we were able to identify 49 comparison students who were determined to be, on average, comparable to the 49 Ingenuity participants across all matching variables.

Table B.1 presents means for each matching characteristic by group, and the data show that they were adequately balanced with no significant differences on any measure. It is notable, however, that administrative records show that 13 of these comparison students who were not participating in Ingenuity were enrolled in Roland Park Elementary/Middle School, and 3 were attending Mt. Royal Elementary/Middle in 2008-09 (their 8th grade year). The remaining 33 comparison students' middle school enrollments were distributed across the district in 20 different schools.

Table B.1
Means for Characteristics Used in Matching Procedure for Ingenuity Middle Grades and Final Comparison Students

	Ingenuity – Middle Grades Only	Comparison – No Ingenuity
% Male	28.6	28.6
% Free/Reduced-price lunch eligible	41.0	51.0
% White	16.3	12.2
% African-American	77.6	85.7
% Asian	4.1	2.0
% Hispanic	2.0	0.0

[5] There were originally 90 students identified as Ingenuity middle grades participants, but 29 continued into the high school Ingenuity program and were not appropriate to include in this part of the analysis. Further, an additional 12 students did not attend a City School high school between 2009-10 and 2012-13, and thus data that would allow us to measure their high school performance were unavailable.

[6] Participant rosters submitted to City Schools by Ingenuity did not contain information for the graduating class of 2007-08 that would allow the identification of Ingenuity middle grades-*only* participants during their 6th-8th grade years, i.e., SYs 2001-02 through 2003-04. Rosters included only information pertaining to 2008 Ingenuity graduates who followed the program into high school. The resulting pool of Ingenuity middle grades participants included 49 students, among whom 30 attended Roland Park Elementary/Middle School while 19 attended Mt. Royal Elementary/Middle School.

[7] Further details about the propensity score matching procedure can be found in Appendix C.

Table B.1
Means for Characteristics Used in Matching Procedure for Ingenuity Middle Grades and Final Comparison Students

	Ingenuity – Middle Grades Only	Comparison – No Ingenuity
5th Grade Attendance Rate	97.9	98.1
5th Grade MSA Math Scale Scores		
Composite	460.6	460.3
Algebra patterns/functions	510.8	507.2
Geometry measures	452.1	451.1
Statistics and Probability	495.1	505.6
Number Relations/Computations	512.1	521.0
Math Processes	460.0	457.6
5th Grade MSA Reading Scale Scores		
Composite	451.9	448.5
General reading	450.2	444.0
Information reading	453.6	452.3
Literary reading	455.3	452.6
N	49	49

Note. No significant differences for any measure. For characteristics where the means were different, the variance within either student group was greater than the mean difference between the groups.

High School Participants. Just as for middle grades-only participants, an initial step was to identify appropriate comparison students for the high school Ingenuity participants. This was done separately for each of the 2008 and 2013 Ingenuity graduating classes. We defined a pool of potential matches for each group by selecting students who: a) started ninth grade at Poly in the same year as the Ingenuity cohort, b) had never participated in Ingenuity themselves, and c) remained in a City Schools high school until they withdrew or graduated so that outcomes could be determined.

Using an identical matching procedure as for identifying suitable comparison students for the middle school component, we matched students according to gender, ethnicity, FARM status, LEP status, special education service receipt, 8th grade daily attendance rate, and middle grades state assessment scores in math and reading. From this estimation, a set of comparison students was identified for each cohort of high school Ingenuity participants.

As shown in Table 2, the matching technique produced sufficiently balanced groups of comparison students for further analysis. For the 2012-13 graduating cohort comprising 28

Ingenuity graduates,[8] 17 comparison students were identified. For the 2007-08 cohort, which included 24 Ingenuity graduates, a different set of 17 comparison students was identified. Virtually all graduates of Ingenuity and their corresponding comparison students attended and graduated from Poly.[9]

Across the variables used to define similarity, few differences between groups remained and none were significant. As compared to all other prospective peers entering Poly in 9th grade (results not presented), the students included as comparison cases for both cohorts were far less likely to qualify for FARMS, had very good attendance in 8th grade (missing fewer than 4 days on average), and achieved scores on their 7th grade Terra Nova and 8th grade MSA assessments that placed virtually all of them above the 90th national percentile, and in the advanced category, respectively.

Table B.2
Means for Characteristics Used in Matching Procedure for High School Ingenuity and Final Comparison Students

	2007-08		2012-13	
	Ingenuity	Comparison	Ingenuity	Comparison
% Male	62.5	70.8	75.0	75.0
% Free/Reduced-price lunch eligible	16.7	16.7	50.0	46.0
% White	33.3	50.0	29.0	21.0
% African-American	50.0	37.5	46.0	61.0
% Asian	12.5	0.0	11.0	7.0
% Hispanic	4.2	12.5	4.0	11.0
% American Indian	0.0	0.0	11.0	0.0
8th Grade Attendance Rate	98.2	98.1	98.2	98.4
7th Grade Terra Nova Math Scale Scores				
Composite	739.4	737.1		
Math Computation	742.7	743.8		
Math Concepts & Applications	735.9	730.3		
7th Grade Terra Nova Reading Scale Scores				
Composite	718.1	717.7		
Reading Comprehension	706.9	713.7		
Reading Vocabulary	728.9	721.2		
8th Grade MSA Math Scale Scores				
Composite			481.3	484.0
Algebra patterns/functions			500.0	504.8

[8] One Ingenuity student from the 2012-13 cohort was excluded from all analyses due to a near-zero probability of identifying an appropriate control or set of control students.

[9] One comparison student for the 2007-08 cohort transferred out of Poly before the end of his/her junior year in high school but graduated from City Schools in the expected amount of time. The remaining comparison students for both graduating Ingenuity cohorts were enrolled at Poly for the entirety of their high school years.

Table B.2
Means for Characteristics Used in Matching Procedure for High School Ingenuity and Final Comparison Students

	2007-08		2012-13	
	Ingenuity	Comparison	Ingenuity	Comparison
Geometry measures			523.6	527.6
Statistics and Probability			503.6	493.7
Number Relations/Computations			512.6	519.2
Math Processes			474.4	473.8
8th Grade MSA Reading Scale Scores				
Composite			441.3	445.4
General reading			439.4	437.8
Information reading			453.8	461.8
Literary reading			440.8	451.6
N	24	17	28	17

Note. No significant differences for any measure. For characteristics where the means were different, the variance within either student group was greater than the mean difference between the groups.

Appendix C
Methodological Details for Propensity Score Matching Procedure

The propensity score method used for the current study was performed to identify comparison (i.e., "control") subjects who, on average, were as similar as possible to subjects who received the "treatment," in this case – Ingenuity participation. Ideally, control subjects must not at any point in time have received the treatment themselves, and any characteristics used to "match" subjects should be measured prior to the start of the treatment.

To account for the first condition, any student identified as an Ingenuity participant according to roster data provided by City Schools was excluded from the pool of potential control subjects. For the second condition, the variables used to match treatment and control subjects included gender, race/ethnicity, special education service receipt, LEP status, FARM status in grade 5 or grade 8 for the middle school and high school component, respectively; and state assessment scale score performance in reading and mathematics in grade 5 for the middle grades-only participants, grade 8 for the 2013 graduates, and grade 7 for the 2008 graduates (differences in choice of grade level for middle grades assessment data resulted from differences in both data availability and achieving a satisfactory data balance between treatment and control groups).

We used the R package *MatchIt* (Ho, Imai, King and Stuart, 2007) to perform the matching algorithms, which estimates a logit regression of the probability, or "propensity" of receiving the treatment. This propensity can be expressed as:

$$\text{Logit}(P) = \text{Log}[P / (1 - P)]$$

This is regressed on relevant background characteristics, and specifically, the algorithm to identify "nearest neighbor" matches was estimated. A post-estimation propensity score, or probability of receiving the treatment for which each treatment case is assigned P(1), is calculated for each case within the pool of potential control subjects, and based on an iterative estimate of the average propensity across potential control cases, suitable control subjects are identified and remaining subjects are discarded. In other words, the matching procedure determines the set of control students who, on average, are most similar to the treatment group.

To ensure covariate balance, the standardized mean differences between treatment and the proposed control subjects for each matching variable were examined before further analyses were performed. The standardized mean difference is calculated by subtracting the control group mean from the treatment group mean and dividing the difference by the standard deviation for the control group. Standardized mean differences of less than .25 are considered appropriate for defining adequate covariate balance between groups (Rosenbaum and Rubin, 1983).

For the current analyses, the number of control students was not always the same as the number of treatment students (i.e., if there were insufficient suitable control subjects for a one-to-one match for each treatment case), so weights generated in the matching procedure were applied to all further comparison analyses in these instances, where the weight for each treatment student is equal to 1, and the weight for any control student is equal to the inverse of the calculated probability score, balanced across the control cases so that the sum of the control weights amounts to the total of the number of treatment cases. This procedure allows for estimating the *average* effect of the treatment on the treated.

Appendix D
Survey Constructs, Corresponding Questions, and Reliability Alphas

Construct	Survey Questions	Cronbach's Alphas for: High School	Alumni
Belongingness within the STEM field (1=Strongly Disagree; 7=Strongly Agree)	"I can relate to the people around me in math and science courses." "I have a lot in common with the other students in my math/science courses." "The other students in my math/science classes share my personal interests."	.90	.82
Expectations for personal satisfaction with a career in STEM (1=Strongly Disagree; 7=Strongly Agree)	"A degree in STEM will allow me to obtain a job that I like." "A degree in STEM will give me the kind of lifestyle I want." "I will feel 'part of the group' on my job if I enter a STEM field." "A degree in STEM will allow me to get a job where I can use my talents and creativity." "Doing well in math will increase my sense of self-worth."	.91	.89
Expectations for success in STEM career (1=Strongly Disagree; 7=Strongly Agree)	"Someone like me can succeed in a math or science career." "Doing well at math will enhance my career/job opportunities." "A degree in STEM will allow me to obtain a well-paying job." "I will be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter a STEM career."	.82	.76
STEM self-efficacy (1=Strongly Disagree; 7=Strongly Agree)	"I can complete the math requirements for most STEM majors." "I can complete the science requirements for most STEM majors." "I can succeed in a STEM curriculum while not having to give up participation in my outside interests (e.g., extracurricular activities, family, or sports)." "I think I can succeed (earn an A or B) in science courses." "I think I can succeed (earn an A or B) in math courses." "I can complete a degree in STEM."	.87	.89
Self-Rating of Knowledge** (1=Major weakness; 5=Major strength)	General Knowledge Knowledge of a particular field or discipline Understanding of national issues Understanding of global issues	.73	.90
Self-Rating of Creative Thinking Skills (1=Major weakness; 5=Major strength)	Critical thinking skills Problem-solving skills Ability to think "outside the box" Ability to think about a problem in a different way from most people	.81	.84
Self-Rating of Soft Skills (1=Major weakness; 5=Major strength)	Ability to manage your time effectively Ability to get along with people of different races/cultures Ambition Leadership abilities	.74	.77

**For the alumni, the Knowledge construct includes only 'General knowledge' and 'Knowledge of a particular field or discipline', while for high school students, the construct includes all four items.