RELATIONSHIP BETWEEN THE PATTERN OF MATHEMATICS AND SCIENCE COURSES TAKEN AND TEST SCORES ON ITED FOR HIGH SCHOOL JUNIORS

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Abstract—Three years of student-level data were used in this study to examine the relationship between student performance on the Iowa Tests of Educational Development (ITED) and the patterns of the mathematics or science courses taken by public high school juniors. The data lead to the conclusion that students who took at least one of the higher-level mathematics or science courses performed better on their tests than their peers who did not take any such courses. The juniors who took two or more higher-level mathematics or three or more higher-level science courses performed significantly better on the tests than the students who took fewer of these courses. Similar results can be found for both male and female students and for all racial/ethnic groups.

Purpose—The purpose of this research is to examine the relationship between students' performance on the Iowa Tests of Educational Development (ITED) and their high school courses taken.

More specifically: in this study an analysis of variance (ANOVA, GLM procedure for unbalanced group sizes) was used to compare the average Standard Score (SS) on ITED Mathematics of the juniors who took higher-level mathematics courses with the juniors who did not. Also, the GLM procedure was used to compare the average SS on ITED science of the juniors who took higher-level science courses with the juniors who did not. Furthermore, the same methodology was applied to gender and five racial/ethnic groups to compare the average SS on ITED Mathematics and Science of the students who took higher-level mathematics and science courses with the students who did not in each subgroup. Secondly, the GLM procedure was used to examine the relationships between student performance on ITED and the number of higher-level mathematics and science courses taken. In summary, the study questions are: Does taking higher-level mathematics and science courses lead to higher test scores? Does taking more higher-level mathematics or science courses lead to better achievement? If the first two questions have positive answers, how significant and how large are the score gaps between students who took higher-level courses and those who did not?

Important—*No Child Left Behind (NCLB) Act*: The goal of the No Child Left Behind Act of 2001 is to monitor the annual progress of all public schools to ensure that 100 percent of public school students are proficient in mathematics, reading, and science by the year 2014. Students' achievement can be improved by developing their skills and enriching their knowledge through the learning process. More specifically, students' success

depends on an efficient school program and a broad curriculum taught by highly qualified teachers along with individual students' hard work and a healthy active network between students, family, and school staff. Assessment is a tool to measure student success and to identify students' weaknesses and strengths that will assist them in their future studies. The current study can provide evidence to the policy makers and educators that will result in high school students improving their achievement.

Core curriculum: During the 2005 session, the Iowa Legislature mandated 1) that all school districts develop a model core curriculum and 2) the establishment of a statewide core curriculum completion rate goal. The model core curriculum focuses on the areas of literacy, mathematics, and science and encourages rigor and relevance in curriculum offerings.

The results of the current study can be shared with educational decision makers as they make core curriculum decisions that will increase high school students' success rate, and the results will provide evidence of the link between course work and student achievement. These findings will also encourage schools to offer more rigorous curriculum and will encourage students to take more higher-level courses.

Project EASIER and Unique Student IDs: In the fall of 2004, after almost twelve years of preparation, the Iowa Department of Education implemented the Iowa Student Identifier System and started to collect statewide individual public school student data through Project EASIER (Electronic Access System for Iowa Education Records). The Student Identifier System provides the opportunities for student data to be accurately tracked across time. Currently, the Department has three years of this type of student-level data, making it possible for the first time in history to link Iowa public high school juniors' achievement data to their three years of high school course work. This study is a validity check for the Project EASIER data collection and an opportunity to open the door to share more research results based on student-level data with entities within the educational community and with the general public.

Methods—*Students and Assessments*: The students in this study consisted of about 36,000 public high school juniors who were enrolled in an Iowa district from 2004-2005 to 2006-2007 and who took the ITED Mathematics or Science in 2006 Fall, 2007 Spring, or 2006-2007 Mid-year. The 2006-2007 juniors' ITED data were received from the Iowa Testing Programs and are certified by each school and district for their NCLB report.

Courses taken: The current study focused on the 2006-2007 juniors' courses taken in mathematics or science in their freshman, sophomore, and junior years. The higher-level mathematics courses include Pre-Calculus, Calculus, AP Calculus, Trigonometry, and AP Statistics. The higher-level science courses include AP Biology, Chemistry, and Physics.

Data Analyses

Phase I attempts to do the following:
To discriminate the average Standard Scores on ITED Mathematics (and ITED Science) of the juniors who took higher-level mathematics courses (and science) from those who did not. The students were separated into two groups based on whether or not they took higher-level mathematics or science courses. Students who took at least one higher-level mathematics (or science) course are identified as Pattern 1, and students who did not take any such courses are identified as Pattern 0. The analyses were conducted using juniors with ITED Mathematics Standard Scores and ITED Science Standard Scores as the dependent variables and the course-taken Pattern as the independent variable. Two groups of separate GLM procedures (an Analysis of Variance with unbalanced data), one group of ITED Mathematics SS vs. higher-level mathematics courses taken (for the test takers in Fall, Spring, and Mid-year) and the other group of GLM procedures, were used for ITED Science SS vs. higher-level science courses taken (for the Fall, Mid-year, and Spring test-takers). The same analysis was applied to each of the gender and five racial ethnic groups.

Phase II attempts to do the following:
- Examine the relationships between the number of higher-level science or mathematics courses taken and juniors' performance on ITED Mathematics and Science.
- Answer the question: Does taking more mathematics or more science courses lead to better achievement?

The GLM procedure was used to test the analysis of variances with juniors' ITED Standard Scores as the dependent variable and the number of higher-level mathematics/science courses taken as the independent variable.

Results and Conclusions—Of the almost 36,000 Iowa public school juniors in this study, about 21 percent took higher-level courses in both mathematics and science, about 3 percent took higher-level mathematics but not higher-level science courses, and 37 percent took higher-level science but not higher-level mathematics courses. About 39 percent of the juniors did not take either higher-level mathematics or science courses. For the group who took both higher-level mathematics and science courses, the average ITED Standard Scores were about 330 for mathematics and science, and for those who did not take higher-level mathematics/science courses, the average ITED scores were about 270. The score differences are over 60 SS points for all three groups of test-takers (Fall, Mid-year, and Spring).

Phase I
Tables 1A to 1C show the descriptive statistics on ITED Mathematics (and Science) Standard Scores for the juniors who did not take any (Pattern 0) higher-level mathematics (and science) and for the juniors who took one or more (Pattern 1) higher-level mathematics (and science) courses. About 23 percent of the juniors in this study took at least one of the higher-level mathematics courses. For the Pattern 1 group, the average ITED Mathematics Standard Scores were 324, 323, and 318 for Fall, Mid-year, and Spring test-takers respectively while the average ITED Mathematics Standard Scores were 282, 283, and 271 for the Pattern 0 group tested in Fall, Mid-year, and Spring. About 77 percent of the juniors were in the Pattern 0 group. The score gap between these two groups was over 40 SS points. The

gap on the ITED Science score was over 40 SS points as well. All analyses with GLM Procedure show the significant F-values ($p<0.0001$ for F-tests). In other words, the juniors who took one or more higher-level science or mathematics courses performed significantly better than the juniors who did not take any of these courses based on their ITED Mathematics and Science Standard Scores. The large effect sizes between the average standard scores for the juniors in course-taken Pattern 1 and Pattern 0 in Fall, Mid-year, and Spring displayed in Table1A to Table 1C for both mathematics and science also support the GLM results.

Table 1A—ITED Mathematics and Science Standard Scores for High School Juniors vs. Their Higher-level Mathematics or Science Courses-Taken Pattern (2006 Fall Test-Takers)

	ITED STANDARD SCORES IN MATHEMATICS			
COURSE-TAKEN PATTERN	MEAN	SD	NUMBER STUDENTS	PERCENT STUDENTS
0	281.8	37.2	16,096	75.1%
1	**323.9**	**27.0**	**5,332**	**24.9%**
Total	292.3	39.4	21,428	
Effect Size			**1.07**	
	ITED STANDARD SCORES IN SCIENCE			
	MEAN	**SD**	**NUMBER STUDENTS**	**PERCENT STUDENTS**
0	274.0	39.4	8,728	40.9%
1	**317.2**	**35.7**	**12,603**	**59.1%**
Total	299.5	42.9	21,331	
Effect Size			**1.01**	

Source: Iowa Department of Education, Project EASIER Files.
Note: Pattern 1 includes the juniors who took at least one higher-level mathematics (or science) course and Pattern 0 includes juniors who did not take any such courses.

Table 1B—ITED Mathematics and Science Standard Scores for High School Juniors vs. Their Higher-level Mathematics or Science Courses-Taken Pattern (2006-2007 Mid-year Test-Takers)

COURSE-TAKEN PATTERN	ITED STANDARD SCORES IN MATHEMATICS			
	MEAN	SD	NUMBER STUDENTS	PERCENT STUDENTS
0	282.8	36.5	7,578	78.7%
1	**323.2**	**26.5**	**2,055**	**21.3%**
Total	291.4	38.4	9,633	
Effect Size			**1.05**	
	ITED STANDARD SCORES IN SCIENCE			
	MEAN	**SD**	**NUMBER STUDENTS**	**PERCENT STUDENTS**
0	274.0	39.6	4,065	42.4%
1	**314.7**	**35.9**	**5,529**	**57.6%**
Total	297.5	42.5	9,594	
Effect Size			**0.96**	

Source: Iowa Department of Education, Project EASIER Files.
Note: Pattern 1 includes the juniors who took at least one higher-level mathematics (or science) course and Pattern 0 includes juniors who did not take any such courses.

Table 1C—ITED Mathematics and Science Standard Scores for High School Juniors vs. Their Higher-level Mathematics or Science Courses-Taken Pattern (2007 Spring Test-Takers)

COURSE-TAKEN PATTERN	ITED STANDARD SCORES IN MATHEMATICS			
	MEAN	SD	NUMBER STUDENTS	PERCENT STUDENTS
0	271.0	47.6	3,918	80.1%
1	**317.9**	**49.4**	**975**	**19.9%**
Total	280.4	51.5	4,893	
Effect Size			**0.91**	
	ITED STANDARD SCORES IN SCIENCE			
	MEAN	**SD**	**NUMBER STUDENTS**	**PERCENT STUDENTS**
0	265.8	49.9	2,392	49.0%
1	**306.9**	**52.8**	**2,488**	**51.0%**
Total	287.3	55.4	4,880	
Effect Size			**0.74**	

Source: Iowa Department of Education, Project EASIER Files.
Note: Pattern 1 includes the juniors who took at least one higher-level mathematics (or science) course and Pattern 0 includes juniors who did not take any such courses.

Tables 2A through 2C show the ITED Mathematics standard score gap by gender and race/ethnicity between the juniors who took higher-level mathematics courses and those who did not, as well as the percent of students who took higher-level mathematics for each group. Racial/ethnic groups are: White, African American, Hispanic, Asian, and American Indian. Although the percent of the higher-level courses taken varied from one group to another, the score gaps (between the students who took and those who did not take higher-level mathematics) and the effect sizes were very large for all racial/ethnic and gender groups. The highest percent of students taking higher-level mathematics courses were Asians. Tables 3A to 3C illustrate similar large gaps in the ITED Science scores. Asians had the highest ITED Science score gaps and also had the largest percent of students who took higher-level science courses. Generally speaking, the standard score gaps and effect sizes between the students in course taken-Pattern 1 and Pattern 0 were slightly larger for the ITED Mathematics than those for the ITED Science.

Table 2A—Differences on ITED Mathematics Standard Scores Between High School Juniors Who Took Higher-level Mathematics Courses and Those Who Did Not, by Gender and Race/Ethnicity (2006 Fall Test-Takers)

	ITED MATHEMATICS SCORE GAP	EFFECT SIZE	% JUNIORS WHO TOOK HIGHER-LEVEL MATHEMATICS
Female	40.4	1.05	24.9%
Male	**43.7**	**1.09**	**24.8%**
White	40.0	1.04	25.8%
African American	**43.9**	**1.12**	**9.6%**
Hispanic	49.6	1.33	9.0%
Asian	**50.6**	**1.15**	**44.0%**
American Indian	45.0	1.26	7.3%
All	**42.1**	**1.07**	**24.9%**

Source: Iowa Department of Education, Project EASIER Files.

Table 2B—Differences on ITED Mathematics Standard Scores Between High School Juniors Who Took Higher-level Mathematics Courses and Those Who Did Not, by Gender and Race/Ethnicity (2006-2007 Mid-year Test-Takers)

	ITED MATHEMATICS SCORE GAP	EFFECT SIZE	% JUNIORS WHO TOOK HIGHER-LEVEL MATHEMATICS
Female	38.4	1.04	21.3%
Male	**42.4**	**1.08**	**21.3%**
White	38.9	1.03	22.2%
African American	**49.0**	**1.34**	**10.0%**
Hispanic	49.2	1.33	8.9%
Asian	**42.8**	**1.04**	**24.2%**
American Indian	29.2	0.80	9.8%
All	**40.4**	**1.05**	**21.3%**

Source: Iowa Department of Education, Project EASIER Files.

Table 2C—Differences on ITED Mathematics Standard Scores Between High School Juniors Who Took Higher-level Mathematics Courses and Those Who Did Not, by Gender and Race/Ethnicity (2007 Spring Test-Takers)

	ITED MATHEMATICS SCORE GAP	EFFECT SIZE	% JUNIORS WHO TOOK HIGHER-LEVEL MATHEMATICS
Female	44.7	0.92	21.0%
Male	**49.5**	**0.92**	**18.9%**
White	43.2	0.83	21.7%
African American	**72.0**	**1.90**	**4.5%**
Hispanic	49.5	1.28	7.3%
Asian	**49.2**	**1.03**	**37.1%**
American Indian	60.3	1.66	22.2%
All	**46.8**	**0.91**	**19.9%**

Source: Iowa Department of Education, Project EASIER Files.

Table 3A—Differences on ITED Science Standard Scores Between High School Juniors Who Took Higher-level Science Courses and Those Who Did Not, by Gender and Race/Ethnicity (2006 Fall Test-Takers)

	ITED SCIENCE SCORE GAP	EFFECT SIZE	% JUNIORS WHO TOOK HIGHER-LEVEL SCIENCE
Female	38.6	0.96	62.5%
Male	**47.5**	**1.05**	**55.8%**
White	42.2	1.00	60.6%
African American	**36.4**	**0.91**	**39.5%**
Hispanic	35.4	0.87	34.2%
Asian	**48.9**	**1.09**	**75.4%**
American Indian	38.3	0.94	35.5%
All	**43.2**	**1.01**	**59.1%**

Source: Iowa Department of Education, Project EASIER Files.

Table 3B—Differences on ITED Science Standard Scores Between High School Juniors Who Took Higher-level Science Courses and Those Who Did Not, by Gender and Race/Ethnicity (2006-2007 Mid-year Test-Takers)

	ITED SCIENCE SCORE GAP	EFFECT SIZE	% JUNIORS WHO TOOK HIGHER-LEVEL SCIENCE
Female	35.5	0.91	60.6%
Male	**45.5**	**1.00**	**54.7%**
White	40.2	0.95	58.6%
African American	**32.9**	**0.86**	**42.9%**
Hispanic	34.9	0.94	43.0%
Asian	**47.9**	**1.06**	**65.9%**
American Indian	39.9	0.90	41.2%
All	**40.6**	**0.96**	**57.6%**

Source: Iowa Department of Education, Project EASIER Files.

Table 3C—Differences on ITED Science Standard Scores Between High School Juniors Who Took Higher-level Science Courses and Those Who Did Not, by Gender and Race/Ethnicity (2007 Spring Test-Takers)

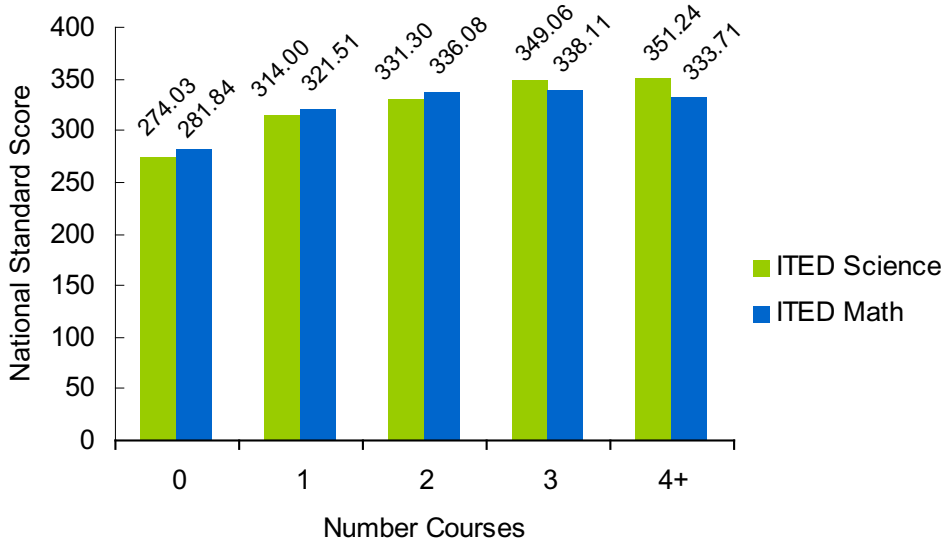
	ITED SCIENCE SCORE GAP	EFFECT SIZE	% JUNIORS WHO TOOK HIGHER-LEVEL SCIENCE
Female	37.8	0.72	53.0%
Male	**44.0**	**0.76**	**49.0%**
White	40.0	0.71	53.2%
African American	**29.0**	**0.72**	**33.2%**
Hispanic	41.2	0.99	38.2%
Asian	**41.6**	**0.83**	**58.5%**
American Indian	36.6	0.89	44.4%
All	**41.1**	**0.74**	**51.0%**

Source: Iowa Department of Education, Project EASIER Files.

Phase II

Figure 1 shows the average ITED Standard Scores by the number of higher-level mathematics/science courses taken by the juniors in this study. On average, as the number of courses taken increases, the average Standard Scores increase. The GLM Procedures show significant F-values for the average ITED Mathematics/Science Standard Scores by the number of higher-level mathematics/science courses taken for the juniors in the study ($p<0.0001$). However, the follow-up tests using Tukey's studentized range (HSD) on the average ITED scores between different combinations by number of higher-level mathematics/science courses taken did not show a significant score difference for the juniors who took three or more higher-level mathematics courses from the juniors who took only two such courses (see Table 4 for results for the Fall test-takers). The follow-up Tukey's test did not show a significant score difference for the juniors who took four or more higher-level science courses from the juniors who took only three such courses (see Table 5 for results for the Fall test takers). The same results were found for the Spring and Mid-year test-takers.

Figure 1—2006-2007 Public High School Juniors' Average ITED Scores by Number of Higher-level Mathematics/Science Courses Taken (2006 Fall Test Takers)



Source: Iowa Department of Education, Project EASIER Files.

Table 4—Tukey's Test for the Average ITED Mathematics Standard Score Gaps Between Numbers of Higher-level Mathematics Courses Taken for High School Juniors (2006 Fall Test-Takers)

NUMBER COURSES TAKEN	DIFFERENCES BETWEEN AVERAGE ITED MATHEMATICS STANDARD SCORE				
	0	1	2	3	4+
0		**39.7*** **	**54.2*** **	**56.3*** **	**51.9*** **
1			14.6***	16.6***	12.2***
2				**2.0**	**-2.4**
3					-4.4
4+					
Number Students	**16,096**	**4,434**	**40**	**417**	**441**
% Students	75.1%	20.7%	0.2%	1.9%	2.1%

Source: Iowa Department of Education, Project EASIER Files.
Note: *** indicates a significant difference at the 0.05 level.

Table 5—Tukey's Test for the Average ITED Science Standard Score Gaps Between Numbers of Higher-level Science Courses Taken for High School Juniors (2006 Fall Test Takers)

NUMBER COURSES TAKEN	DIFFERENCES BETWEEN AVERAGE ITED SCIENCE STANDARD SCORE				
	0	1	2	3	4+
0		**40.0*** **	**57.3*** **	**75.0*** **	**77.2*** **
1			17.3***	35.1***	37.2***
2				**17.8*** **	**19.9*** **
3					2.2
4+					
Number Students	**8,728**	**10,595**	**1,696**	**258**	**54**
% Students	40.9%	49.7%	8.0%	1.2%	0.3%

Source: Iowa Department of Education, Project EASIER Files.
Note: *** indicates a significant difference at the 0.05 level.

The next question to answer is: Does taking more mathematics/science courses lead to a high test score or do higher-level math/science courses taken result in a better performance? The author selected all the juniors in this study who took four or more mathematics courses without a higher-level mathematics course compared to juniors who took four or more courses in mathematics with at least one higher-level course. The average ITED Mathematics score for those who took more mathematics courses without any higher-level courses (about 7 percent of the all juniors in the study) were 46, 41, or 47 standard score points lower than the group who took more mathematics courses that included at least one higher-level course (4.2 percent) for the Fall, Mid-year, and Spring test-takers, respectively. There were 636 or 1.8 percent of the juniors who took at least four science courses without any higher-level science courses, and the average ITED Science scores for the groups were about 48, 46, and 44 SS points lower than the average ITED Science scores for the 3,543 (10.1 percent) juniors who took four or more science courses that included higher-level courses for the Fall, Mid-year, and Spring test-takers, respectively. Again, the higher-level courses taken, not simply more courses taken, is the significant factor associated with the high performance of Iowa public high school juniors.

The evidence from the examinations between the juniors' performance on the Iowa Tests of Educational Development Mathematics and Science and their high school higher-level mathematics or science courses taken shows that the juniors who took at least one target course in the study (higher-level) performed better on their tests than the juniors who did not take such course. The findings were true for all racial/ethnic groups and for female and male students. The high school juniors who took two higher-level mathematics or three higher-level science courses performed significantly better on the tests than the students who took fewer such courses.

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