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Relationship between Course Placement Criteria and Mathematics Achievement in an All-Boys Catholic School

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Abstract: This study explored the mathematics course placement process for incoming students in an all-boys Catholic high school. The sequential nature of mathematics significantly impacts students' opportunity to learn; moreover, the mathematics course taken by a student during ninth grade can have far-reaching effects. Previous studies have found that ninth-grade students enrolled in Geometry, rather than Algebra 1, have a greater chance of completing advanced mathematics courses and experiencing increased mathematics success. Thus, adequately prepared students should be placed in Geometry whenever possible. To aid this effort, this study investigated whether a relationship exists between course placement criteria and future mathematics achievement. The study sample was comprised of students who graduated from the subject high school between 2015 and 2019 (N = 1067). The placement criteria examined were Acuity Algebra Proficiency Test results, High School Placement Test mathematics scores, and eighth-grade teacher recommendations. ACT mathematics scores were used as measures of success; binary logistic regression was utilized to determine strength of association between placement criteria and future mathematics achievement. Results indicate that Acuity test performance is strongly associated with future mathematics achievement, while combinations of placement criteria are more effective than individual course placement measures. Implications for further research are discussed.

Keywords: mathematics achievement, course placement, opportunity to learn, algebra for all, sequences of learning, single-sex education

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As students advance from middle school to high school, a significant element in the high school enrollment process is ninth-grade mathematics course placement. The mathematics course taken by a student in ninth grade will often have far-reaching effects. Researchers have long argued that Algebra 1 acts as a gateway course regarding high school mathematics achievement (Smith, 1996); success in Algebra 1 creates a pathway to higher-level mathematics. Stevenson et al. (1994) note that the sequential nature of mathematics significantly impacts students' opportunities to learn. If students begin high school in Geometry rather than Algebra 1, they have a greater chance of progressing further along the mathematics course sequence and subsequently experiencing greater mathematics success (Champion & Mesa, 2018). Keeping students on-schedule within this accepted mathematics course sequence is crucial to both student mathematics achievement in high school as well as student success in STEM-related studies in higher education (Finkelstein et al., 2012).

To address keeping students on-schedule, some educators and policy makers advocate an Algebra for All (AFA) approach, whereby students are exposed to Algebra 1 as early as possible. However, several studies have determined that the timing of student exposure to Algebra 1 is less significant than student preparedness for Algebra 1 (Finkelstein et al., 2012; Liang et al., 2012; Spielhagen, 2006). Thus, educators continue to seek a balance between pushing students into advanced ninth-grade mathematics courses and determining student preparedness to take these courses. This topic is of particular importance to Catholic schools, as declining enrollments require Catholic schools to work harder at recruiting students through demonstrated school effectiveness (Ariemma, 2012). Schools demonstrating the ability to consistently place students into challenging yet appropriate mathematics courses (subsequently setting those students up for future success) may realize a competitive advantage in their efforts to attract students.

From 2011 to 2019, a Catholic archdiocese in the midwestern United States administered the Acuity Algebra Proficiency Test in an attempt to measure students' Algebra 1 proficiency. Test results were used in combination with High School Placement Test (HSPT) scores, course grades, and teacher recommendations to determine ninth-grade course placement. The present study investigated the relationship between these course placement criteria and future mathematics success for students enrolled in an all-boys Catholic high school in the subject archdiocese. The study explored whether a significant relationship exists between the Acuity Algebra Proficiency Test and eventual mathematics achievement in high school, as measured by the American College Test (ACT). The study also examined other course placement measures (both individually and in multiple combinations) for any significant relationship between these placement measures and eventual high school mathematics achievement as measured by the ACT.

Review of the Literature

The Sequential Nature of Mathematics Education

Unlike many other academic subjects, mathematics education generally unfolds along a systematic sequence of courses that have been "nationally institutionalized without being federally prescribed" (Stevenson et al., 1994, p. 196). Mcfarland (2006) identified two prevalent four-year mathematics course sequences for students in U.S. high schools. The standard sequence is typically a) Algebra 1, b) Geometry, c) Algebra 2, and d) Precalculus. The advanced sequence of courses is a) Geometry, b) Algebra 2, c) Precalculus, and d) Calculus.

Given the sequential nature of mathematics curricula, Algebra 1 is often viewed as a "gatekeeper" course (Dougherty et al., 2014). Students who take Algebra 1 in eighth grade and move into Geometry in ninth grade are at an advantage over students who are placed in Algebra 1 as ninth-grade students (Kurlaender & Jackson, 2012; Smith, 1996; Stevenson et al., 1994). Smith (1996) conducted a study of approximately 7,000 high school students to determine achievement differences between students who completed Algebra 1 in eighth grade versus ninth grade. She found that students who completed Algebra 1 in eighth grade rather than ninth grade a) were more likely to take Calculus in high school; b) were more likely to complete a mathematics course during senior year; and c) scored higher on a senior-year mathematics achievement test. Aligning with the earlier work of Stevenson et al. (1994), Smith (1996) concludes that completion of Algebra 1 in eighth grade functions as a "critical credential, regulating access to advanced coursework in mathematics" (p. 150).

Current research continues to validate the earlier work of Smith (1996) and Stevenson et al. (1994) regarding the relationship between ninth-grade mathematics course and future mathematics achievement. Using data from the High School Longitudinal Study, Champion & Mesa (2018) examined a nationally representative sample of approximately 15,000 students and found a strong relationship between a student's ninth-grade mathematics course and the highest level of mathematics course taken. When compared to a student who starts high school in Algebra 1, a student who starts high school beyond Algebra 1 is over twice as likely to complete Precalculus and over eight times as likely to complete Calculus; thus, students who take Geometry in ninth grade are at an advantage over students who take Algebra 1. Many educators and policy makers therefore advocate for greater student access to Algebra 1 in eighth grade.

Algebra for All

The push for greater and earlier student access to Algebra 1 began during the 1990s (Viadero, 2010). Educators and policy makers have increasingly viewed Algebra 1 as the gateway to future mathematics achievement. This increase in emphasis on Algebra 1 eventually became an educational movement known as "Algebra for All" (AFA), rooted in the idea that increased access to Algebra 1 leads to increased student performance in mathematics. In one of the earliest studies of AFA policy results, Smith (1996) determined that students who took Algebra 1 in eighth grade generally advanced further in high school mathematics programs than students who took Algebra 1 in high school. However, this conclusion was strongly influenced by the highly sequential nature of mathematics curriculum in U.S. high schools (Smith, 1996; Stevenson et al., 1994). Nonetheless, the AFA movement continued to build momentum through the 1990s and well into the 2000s. In 2008, the National Mathematics Advisory Panel recommended that students should take Algebra 1 as early as possible, and that school districts should work to find ways to increase student enrollment in Algebra 1 during the eighth grade (Panel, 2008).

As student access to Algebra 1 began to increase, researchers began to study the effectiveness of the AFA approach. Research on the effectiveness of AFA is decidedly split. Several studies found that AFA affects students negatively (Allensworth et al., 2009; Domina, 2014; Domina et al., 2015; Liang et al., 2012). Researchers have concluded that the results of an AFA approach may not be comparable across different settings, specifically pointing to the far-reaching effects that both students and schools experience as a result of increased eighth-grade Algebra 1 enrollment (Domina et al., 2015). Additionally, studies found that many unprepared students who were pushed into Algebra 1 experienced a decrease in mathematics achievement (Allensworth et al., 2009; Domina, 2014; Liang et al., 2012). In each of these scenarios, the AFA goal of increased Algebra 1 access took precedence over whether students were necessarily prepared to take Algebra 1. According to Finkelstein et al. (2012), the timing of a student's enrollment in Algebra 1 is less important than the student's preparedness to take Algebra 1, and schools should take care to only enroll students in Algebra 1 when students are ready to take it.

However, several studies have concluded that increasing access to Algebra 1 could lead to positive results. Hallinan (1991) determined that tracking—grouping students by ability—creates unequal learning opportunities for students, a result that supports an untracked AFA approach. Burris et al. (2004) provide additional support for an untracked AFA approach; these researchers found that transforming a tracked grade school mathematics program into an untracked program led to increased student mathematics achievement in high school. Spielhagen (2006) studied the impact of taking Algebra 1 in eighth grade versus ninth grade by focusing on students with similar entrance credentials, some of whom were selected to take eighth-grade Algebra 1 and some of whom were not. Even when analyzing students with similar entrance credentials, the study found that students granted access to Algebra 1 in eighth grade demonstrated greater achievement in advanced mathematics courses, greater enrollment in advanced mathematics courses, and increased college attendance rates versus students who did not have access to Algebra 1 in eighth grade.

Student Placement into Ninth-Grade Mathematics Courses

As the research demonstrates, no consensus exists regarding the effectiveness of AFA. However, an important takeaway from the literature is the need for educators to exercise caution when placing students into mathematics courses, as students who are placed incorrectly can be negatively impacted (Dougherty et al., 2014; Flexer, 1984). As an example, a 2012 study of community colleges found that roughly one fourth of students placed in remedial mathematics classes could have been successful in college-level mathematics courses (Belfield & Crosta, 2012). These community colleges were using the ACT Compass test and the ACCUPLACER test from the College Board. In 2015, ACT decided to discontinue the Compass test due to the high number of community college students who were being placed inappropriately as a result of the test (Fain, 2015). The study provides a cautionary note against using a single measure for course placement purposes.

Assessing Algebra 1 Proficiency

As noted, educators must exercise caution when deciding whether a student should take Algebra 1 or Geometry in ninth grade, as research clearly shows the far-reaching impact of the ninth-grade course assignment. As part of the course assignment process, student proficiency in Algebra 1 should be quantified as accurately as possible. However, educators must take care when using standardized test scores to measure student proficiency. Koretz (2008) notes that a standardized test score "is an estimate, and the true value lies within a band of uncertainty that surrounds the estimate obtained" (p. 23). Furthermore, Dunne et al. (2012) proposes that systemic summative assessment, while useful as a measure of an entire school or district, does not provide a useful measure of individual student proficiency; rather, this type of assessment should be used in conjunction with classroom-based measures to determine student proficiency. Additionally, Huang et al. (2014) examined the efficacy of two standardized tests in determining mathematics course placement in California middle schools; results demonstrate that the tests were more effective at student course placement when viewed together rather than separately, supporting the practice of not relying on a single standardized measure of proficiency (Dunne et al., 2012; Ketterlin-Geller et al., 2018).

Regardless of the measure(s) of proficiency used, some students will be forced to repeat Algebra 1. Educators must work to avoid unnecessary repetition of Algebra 1 whenever possible. Fong et al. (2014) examined the performance of California students who repeated Algebra 1 and found that unnecessary repetition of Algebra 1 can negatively impact student achievement. Schiller and Hunt (2011) conclude that many students are forced to repeat Algebra 1 in high school due to a lack of appropriate coordination and trust between the high schools and middle schools. Thus, communication between schools is an important component of the placement process.

Acuity Algebra

The Acuity Algebra Proficiency Test is a standardized measure of student proficiency in Algebra 1; the test was created in 2007 by CTB/McGraw-Hill (Newswire, 2007). The Acuity Algebra Proficiency Test is a 32-item test that measures algebra proficiency and student preparedness to move into advanced mathematics courses. The Acuity system was highly lauded when it was launched; the Software and Information Industry Association honored Acuity as the "Best Student Assessment Solution" in 2009 and 2010 (Newswire, 2010). However, evaluations of Acuity's efficacy have been difficult to locate; several efficacy studies that have been located were funded by CTB/McGraw-Hill, the parent company of the Acuitysystem. One such study (Wayman et al., 2009) determined that Acuity is "a powerful, effective system with great potential to provide added knowledge to teachers" (p. 30). An independent study of 59 Indiana elementary schools found Acuity to have a positive effect on mathematics achievement when used as an interim assessment (Konstantopoulos et al., 2013). In 2015, CTB/McGraw-Hill sold off its summative testing divisions in order to focus on classroom-level resources for students and teachers (Cavanaugh, 2015). Very little information concerning Acuity has been published since 2015.

Key Conclusions from the Literature

One important conclusion from this review of the literature concerns the far-reaching impact of ninth-grade mathematics placement; the sequential nature of mathematics curricula sets students on a relatively fixed path based on the mathematics course they take in ninth grade. Another conclusion is the lack of consensus surrounding the AFA approach to mathematics education. Some studies have found the approach beneficial to students; other studies have demonstrated that the approach negatively impacts student achievement. This lack of consensus points to the need to address both access and aptitude when placing students in algebra courses (Spielhagen, 2006). A final conclusion from the research involves the measurement of student proficiency in algebra. Rather than relying on a single summative assessment, studies used several measures to determine student proficiency.

The present study examined the process currently used to place students in ninth-grade mathematics classes at an all-boys Catholic high school in the midwestern United States. From 2011 to 2019, the Acuity Algebra Proficiency Test was used as part of the ninth-grade mathematics course placement process by the subject high school as well as by other high schools in the same Catholic archdiocese. As noted above, the Acuity test has since been discontinued by McGraw-Hill; this has required the subject archdiocese and other users of Acuity to identify a new test or process for measuring algebra proficiency. However, the question remains as to whether Acuity was a useful tool for assessing algebra proficiency. This study addressed the following research questions:

1. Does a relationship exist between the Acuity Algebra Proficiency Test and mathematics achievement as measured by the ACT for students enrolled in an all-boys Catholic high school?

2. What combination of course placement metrics is most strongly associated with future mathematics achievement as measured by the ACT for students enrolled in an all-boys Catholic high school?

Methods

The structure of this study was influenced by the earlier work of Domina (2014) and Huang et al. (2014). These studies investigated both the use of standardized test results to determine student placement in eighth-grade Algebra 1 as well as student success in that course. By contrast, the research for this study consisted of a quantitative analysis of data related to ninth-grade mathematics course placement and subsequent mathematics achievement for students in the subject high school as measured by ACT score. Data sources related to student mathematics course placement included a) Acuity test data, b) eighth-grade teacher recommendations, and c) student mathematics scores on the HSPT, a popular private school placement test. Subsequent student achievement in high school mathematics was measured by ACT mathematics scores. Catholic schools often convince potential students to attend based on the promise of rigorous academic preparation, and ACT scores are an important component of this. Furthermore, a study by Fleming et al. (2018) found that Catholic school students experience greater post-secondary success than their public school counterparts. Given that robust ACT scores are often necessary to continue on the post-secondary path, the use of ACT scores as a measure of mathematics achievement seemed reasonable.

Participants and Data Collection

This study used archival data obtained from the subject high school. Data consisted of a convenience sample of all available students who enrolled in the subject high school from 2011 to 2015 and graduated between 2015 and 2019. The following archival data were collected from the subject high school's database: a) Acuity Algebra Proficiency test scores, b) HSPT mathematics scores, c) eighth-grade teacher recommendations for ninth-grade mathematics course, and d) ACT mathematics scores. The initial data set produced a sample size of N = 2,118 based on HSPT mathematics scores. However, all these students did not end up enrolling at the subject high school. Additionally, several students across all five years of the sample had incomplete data sets; these students were eliminated from the sample, resulting in a final sample size of N = 1,067.

Data Analysis

This study investigated how different placement criteria relate to student mathematics achievement. Placement criteria were examined individually and in multiple combinations. For this reason, a series of binary logistic regression (BLR) models were used to analyze the relative influence each predictor variable had on the selected outcome measure. The logistic regression models also provided a probability of success given a specific set of predictor variable inputs.

Predictor Variables

The predictor variables in this study were the criteria used for ninth-grade mathematics course placement: a) Acuity test score, b) HSPT mathematics score, and c) eighth-grade teacher recommendation. In SPSS, these variables were coded as *Acuity*, *HSPT,* and *Rec*, respectively. The *Acuity* test contains 32 questions; scores are reported both as a scale score and as the number of questions answered correctly. Since the BLR models describe how a single-unit increase in a predictor variable affects the likelihood of achieving a given outcome, it made sense to use the number of questions answered correctly for the *Acuity* predictor variable. The HSPT mathematics score is a standard score reported by the Scholastic Testing Service (STS), ranging from 200 to 800. The *HSPT* predictor variable used this standard score. Finally, eighth-grade teachers were able to recommend students for five different courses: a) Algebra 1, b) Honors Algebra 1, c) Geometry, d) Honors Geometry, and e) Advanced Honors Geometry/Algebra 2. For the purpose of this study, these recommendations were separated into two groups: a) Algebra 1 and b) Geometry. The *Rec* predictor variable was coded as a binary variable, where an Algebra 1 recommendation was coded as *Rec* = 0 and a Geometry recommendation was coded as *Rec* = 1. Descriptive statistics for student data are displayed in Table 1.

Dependent Variable

The dependent variable in this study was student mathematics achievement as defined by student ACT mathematics scores. According to T Theaker and Johnson (2012), students seeking admission to a four-year state university should strive for a benchmark ACT score of 24 out of 36. Additionally, students seeking admission to top-tier public universities should strive for a benchmark score of 29, and students seeking admission to top-ranked universities (such as Ivy League schools) should strive for a benchmark of 32.

These benchmark scores were addressed individually to measure different levels of mathematics success. All BLR analyses were conducted three separate times in order to utilize the three different ACT benchmark scores. ACT benchmark scores were converted into binary output for the BLR models. When an ACT score of 24 was used as the outcome measure, all students with an ACT score greater than or equal to 24 were coded in SPSS as *ACT24* = 1 while students with a score below 24 were coded as *ACT24* = 0. When ACT scores of 29 and 32 were used as the outcome measure, students were coded in SPSS in a similar manner for the outcome variables *ACT29* and A*CT32*, respectively.

BLR Models

In the first set of BLR analyses, the *Acuity* predictor variable was considered individually to determine whether a relationship existed between student performance on the Acuity test and future success in mathematics. Three different models were created, one for each ACT benchmark score. In the second set of BLR analyses, all three predictor variables were considered individually in order to examine how strongly each course placement measure was associated with future ACT performance, measured once again by three different benchmarks. Finally, the third set of BLR analyses utilized all possible combinations of the predictor variables to examine how strongly each combination of course placement measures was associated with future ACT performance. Equation 1 displays the general equation used for the different BLR analyses:

$$log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 \times (predictor\ 1) + \beta_2 \times (predictor\ 2) + \beta_3 \times (predictor\ 3) \quad (1)$$

When placement criteria were examined individually, Equation 1 contained only one predictor term. When placement criteria were examined in combinations, the second and third predictor terms were included as necessary. Once the BLR model generated the appropriate β coefficients, a *probability of success* could be calculated for a given set of input criteria. Equation 2 displays how this probability of success was calculated:

$$p = \frac{e^{\beta_0 + \beta_1 \times (predictor\ 1) + \beta_2 \times (predictor\ 2) + \beta_3 \times (predictor\ 3)}}{1 + e^{\beta_0 + \beta_1 \times (predictor\ 1) + \beta_2 \times (predictor\ 2) + \beta_3 \times (predictor\ 3)}} \quad (2)$$

Results

Relationship Between Acuity and Mathematics Outcomes

To determine whether a relationship existed between *Acuity* test scores and future mathematics success, a series of three BLR models were created using Acuity as the predictor variable. Each BLR model used a different ACT benchmark (24, 29, and 32) as the outcome measure. For each outcome measure, a base (null) model was created using no predictor variables. This base model was then compared to the final BLR model to determine whether using the *Acuity* predictor variable was an improvement over using no predictor variable. Data were analyzed using SPSS data analysis software. The results of these analyses can be found in Tables 2, 3, and 4. Table 2 displays the results for an ACT benchmark of 24, while Tables 3 and 4 display the results for benchmarks of 29 and 32, respectively. For each table, the first row displays the base model while the second row displays the model with the *Acuity* predictor variable.

To assess goodness of fit for the three *Acuity* predictor models, the SPSS Omnibus Test of Model Coefficients was employed. For all three predictor models, χ^2 values were found to be significant ($p < 0.05$); thus, all three models fit the data well. Further examination of the χ^2 values revealed additional information. The SPSS software uses a difference of -2 log likelihood (-2LL) values to determine a χ^2 value for these BLR models. A higher χ^2value indicates a greater improvement over the base model. For each of the three outcome measures, the -2LL value was lower for the final model than for the base model, which indicated that the predictor models all provided a better fit for the data than the base models. However, all three models did not demonstrate the same level of improvement over the base model. The predictor models for ACT benchmarks of 24, 29, and 32 had χ^2values of 469.15, 461.65, and 280.94, respectively. This means that the *Acuity* predictor model showed greater improvement over the base model for outcome measures of 24 and 29 than for an outcome measure of 32.

This result is consistent with the predictive accuracy of each model as determined by SPSS. When compared against the student data set, the *Acuity* model correctly predicted student achievement of the first benchmark (ACT > 24) 80.1% of the time, which was 12.5% better than the base model with no predictors. For a benchmark of 29, the predictor model was accurate 83.5% of the time, which was 9.6% better than the base model's performance. Finally, the predictor model performed 2.6% better than the base model for a benchmark score of 32 (predictor model accuracy = 89.3%). Thus, in all three cases, the *Acuity* model performed better than the base model with no predictors. However, similar to the χ^2 comparison, the *Acuity* models for outcome measures of 24 and 29 showed greater improvement over the base model than for an outcome measure of 32. Further supporting this result, the Nagelkerke R^2 for outcome measures of 24 and 29 were 0.497 and 0.515, respectively, indicating that these models explained approximately 50% of the variance in the data. The Nagelkerke R^2 for the outcome measure of 32 was 0.426, meaning that even though this model explained around 43% of the variance in the data, it still did not perform as well as the *Acuity* models for outcome measures of 24 and 29.

Based on the BLR analyses, the β coefficient for the *Acuity* predictor variable was found to have significance in all three predictor models ($p < 0.001$). The odds ratios for each β ranged from 1.414 for ACT > 24 to 1.372 for ACT > 32. This means that, across the three BLR models, an increase of 1 correct question on the Acuity test corresponded to an increase of approximately 40% in the odds of reaching a given benchmark. These results were consistent across the three different outcome measures, implying that there was in fact a strong relationship between Acuity performance and future mathematics achievement as measured by ACT score.

The probability of a student reaching a particular ACT benchmark was calculated using Equation 2. The Acuity technical manual states that answering 17 or more questions correctly demonstrates "high mastery," while answering 8 to 16 questions correctly demonstrates "moderate mastery" (CTB/Mcgraw-Hill., 2007). Based on the results of the BLR analysis, a student answering 17 questions correctly on Acuity had an 82% probability of achieving an ACT score of 24 while a student scoring answering 16 questions correctly still had a 76% probability of achieving the same ACT score.

Placement Criteria Examined Individually

Next, all three predictor variables were considered individually in order to examine how strongly each course placement measure was associated with future success in mathematics. Additional BLR models were created using *HSPT* and *Rec* as individual predictors. Like the BLR models for the *Acuity* predictor, these additional BLR models for *HSPT* and *Rec* were created in groups of three, utilizing the same three ACT benchmarks as the outcome measure; in total, nine BLR models were considered. The results of these additional BLR models are displayed in Tables 2, 3, and 4. The first row of each table presents the base model for a given outcome measure; the next three rows display the results of the BLR analyses for the individual predictor variables based on the given outcome measure.

All nine predictor models were found to have significance regarding goodness of fit according to χ^2 values from the Omnibus Test of Coefficients (p < 0.001). Additionally, all β coefficients for the predictor variables were found to have significance in all nine predictor models (p < 0.001 based on Wald χ^2). Based on -2LL values, all models showed improvement over the base model, with the *HSPT* predictor consistently showing the greatest improvement and the *Rec* predictor consistently showing the least improvement. This trend continued when comparing the Nagelkerke R^2 values for each model. Across the three outcome measures, the *HSPT* predictor explained between 45% and 55% of the variance in the data, the *Acuity* predictor explained between 43% and 52% of the variance, and the *Rec* predictor explained between 23% and 37% of the variance. Based on these results, Acuity results and *HSPT* scores both proved to be stronger predictors than teacher recommendation when looking at -2LL values and Nagelkerke R^2 values.

Similar results were seen when examining the predictive accuracy of the models relative to the data: *HSPT* consistently performed the best while *Rec* performed the worst. The greatest discrepancy in predicative accuracy occurred for an outcome measure of 29; the HSPT model achieved a predictive accuracy of 84.2%, while the *Rec* model was only accurate 73.9% of the time. Furthermore, for outcome measures of 29 and 32, the teacher recommendation predictor showed no improvement in predictive accuracy over the base model.

Looking more closely at *Acuity* and *HSPT*, it is clear that they both performed well as predictors. For outcome measures of 29 and 32, *Acuity* and *HSPT* produced extremely similar results for predictive accuracy relative to the data set, with *HSPT* performing slightly better in both cases. The only substantial difference in the two predictors occurred for the ACT benchmark of 24, where

HSPT performed measurably better than *Acuity* according to Nagelkerke R^2(0.552 vs. 0497), χ^2(537.413 vs. 469.145), and predictive accuracy (82.8% vs. 80.1%).

While the predictor models based on the *Rec* variable did not demonstrate the same level of predictive accuracy as the *Acuity* or *HSPT* predictors, these models did yield important results. The odds ratios for the three *Rec* predictor variables indicated that students who were recommended for Geometry were 15.6 times more likely (ACT ≥ 24), 18.1 times more likely (ACT ≥ 29), and 20.1 times more likely (ACT ≥ 32) to achieve a given ACT score than students recommended for Algebra 1. These results agree with prior research on the advantage of enrolling in Geometry in ninth grade instead of Algebra 1 (Champion & Mesa, 2018; Kurlaender & Jackson, 2012; Smith, 1996; Stevenson et al., 1994).

One final note for this section: As the ACT benchmark increased, all models showed a general decrease in improvement over the base model when looking at -2LL values, Nagelkerke R^2, and predictive accuracy. The only exception was the Nagelkerke R^2 value for the *Acuity* predictor, which increased from 0.497 to 0.515 when the ACT benchmark was increased from 24 to 29.

Combinations of Placement Criteria

Finally, the three predictors were analyzed in different combinations to examine whether any combinations of placement criteria were strongly associated with future mathematics success. Four additional BLR predictor models were created for each of the three different ACT benchmarks. The results of these additional BLR models are displayed in Tables 2, 3, and 4. The first row of each table presents the base model for a given outcome measure; the next three rows display the results of the BLR analyses for the individual predictor variables; and the final four rows display the results of the BLR analyses for different combinations of the predictor variables.

When considering the 12 new BLR models created with predictor variable combinations, all 12 models were found to have significance regarding goodness of fit according to χ^2 values from the Omnibus Test of Coefficients ($p < 0.001$). Additionally, all β coefficients for the predictor variables were found to have significance in all predictor models ($p < 0.05$ based on Wald χ^2), with one exception: the β coefficient for *Rec* in the *Acuity/HSPT/Rec* model for an outcome of 32 ($p > 0.05$).

When -2LL and Nagelkerke R^2 values were examined, all predictor combinations demonstrated an improvement over the individual predictor models with one exception—the *Acuity/Rec* combination did not perform as well as *HSPT* by itself for any of the three outcome measures. This trend continued when predictive accuracy was examined, as HSPT produced a higher predictive accuracy than the *Acuity/Rec* combination for all three ACT benchmarks.

Identifying which predictor model demonstrated the greatest improvement over the base model proved challenging, as improvement varied by ACT benchmarks as well as by goodness of fit measures. For each of the three ACT benchmarks, the model that contained all three predictor variables—*Acuity, HSPT,* and *Rec*—showed the greatest improvement over the base model when -2LL and Nagelkerke R^2 values were examined. However, when predictive accuracy was examined, the *Acuity/HSPT* combination showed the greatest improvement over the base model for ACT benchmarks of 24 and 29. Meanwhile, the *HSPT/Rec* combination showed the greatest improvement for an outcome of 32.

Further examination of predictive accuracy revealed additional insights. Table 5 displays the average predictive accuracy of three different model groupings: a) the base model, b) the single-predictor models, and c) the multiple-predictor models. The data demonstrate several important trends. First, the average improvement over the base model decreased as the ACT benchmark score increased. Second, the multiple-predictor models showed a greater average improvement over the base model than the single-predictor models. The greatest improvement occurred for the ACT benchmark of 24, while the benchmark of 32 saw the least improvement. Finally, the greatest disparity in average improvement over the base model occurred for the ACT benchmark of 29. For this benchmark, the multiple-predictor models showed 4.6% more improvement than the single-predictor models, a wider gap than was observed for the benchmarks of 24 (3.6%) and 32 (1.2%).

Discussion and Conclusion

Student mathematics achievement in high school is strongly influenced by the course a student takes in ninth grade; students who take Geometry during ninth grade generally experience higher levels of achievement than students who take Algebra 1 (Champion & Mesa, 2018; Kurlaender & Jackson, 2012; Smith, 1996; Stevenson et al., 1994). If students demonstrate adequate preparedness, educators should make every effort to place incoming ninth-grade students in Geometry. For this approach to work, a sound course assignment process is crucial in determining student preparedness for Geometry.

This study examined the course assignment process used at a single high school over a five-year period. Specifically, the study looked for any relationship between course placement criteria and future ACT performance. Results indicate that performance on the Acuity Algebra Proficiency Test was strongly related to future ACT performance. According to the Acuity technical manual, a score of 17 out of 32 on the Acuity test demonstrates "high proficiency" while a score in the 8–16 range demonstrates "moderate proficiency" (CTB/Mcgraw-Hill., 2007). The subject school's current process uses an Acuity score of 17 as the minimum score needed for placement in Geometry. However, results indicate that a student who scored 16 was only slightly less likely than those who scored 17 to achieve an ACT score of 24. Given this outcome, schools should consider giving greater Geometry access to students who demonstrate moderate proficiency on a standardized Algebra 1 proficiency test.

Results also demonstrate that combinations of placement criteria were much more effective than individual placement measures at predicting future success. While the Acuity test performed well as an individual predictor, the use of all three predictors generally produced the best results, a conclusion supported by prior research (Dunne et al., 2012; Ketterlin-Geller et al., 2018). Since the Acuity test has been discontinued, schools should work to find a suitable replacement for measuring algebra proficiency; failure to find a replacement could result in decreased accuracy in student course placement.

Finally, results clearly indicate that the prediction models performed better for lower ACT scores than for higher ACT scores. This outcome is likely due to several factors. An ACT score of 24 requires proficiency in basic algebra; an ACT score of 32 requires proficiency in advanced algebra and trigonometry. The prediction models relied solely on information related to students' basic algebra proficiency; as such, they could not account for future difficulties students may have encountered in high-level mathematics courses. Additionally, the percentage of students in the sample achieving an ACT ≥ 32 is very low (13.3%) compared to the percentage achieving an ACT ≥ 24 (32.4%), giving the predictor models very little room for improvement over the base model for higher ACT scores.

Limitations

One limitation of the study's results is their lack of generalizability. The study focused exclusively on an all-boys Catholic high school, so results will be not be generalizable to all-girl, mixed-sex, or non-Catholic school environments. Another limitation of the study is its focus on Acuity Algebra Proficiency Test results. As the Acuity test has been discontinued, the positive findings relative to Acuity will not be useful to other schools insofar as this particular test is concerned.

Implications for Future Research and Practice

Study findings highlight several areas for future research. While this study focused on an all-boys Catholic high school, future research could extend this to all-girl, mixed-sex, or public-school settings. Another area for future research concerns the search for Acuity's replacement as a component of the student placement process. The subject school and associated archdiocese have already chosen a successor to Acuity: the NWEA MAP Algebra 1 assessment. Future research could compare the effectiveness of the MAP Algebra 1 assessment against the demonstrated effectiveness of the Acuity Algebra Proficiency Test. Finally, this study did not collect data concerning ninth-grade course enrollment, only course recommendations; subsequent studies could examine the effects of following or ignoring eighth-grade teacher recommendations. Research of this nature would build nicely on the foundation laid by this study and continue the important work of improving student learning through proper course placement.

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Table 1
Descriptive Statistics for Student Data

	M	*SD*	*Low*	*High*
Acuity Correct Answers	16.58	6.074	4	32
HSPT Math Score	527.96	100.14	269	800
Teacher Recommendation*	0.52	0.50	0	1
ACT Math Score	25.57	4.89	13	36

**Note: Algebra 1 recommendation = 0; Geometry recommendation = 1*

Table 2

BLR Analyses for Different Combinations of Placement Criteria (ACT ≥24)

	Predictor	*β*	*df*	*p*	*Odds Ratio*	*-2 Log Likelihood*	X^2	*Nagelkerke* R^2	*Predictive Accuracy*
Null Model						1344.524			67.6%
Acuity	Acuity	0.347	1	.000	1.414	875.379	469.145*	0.497	80.1%
	Constant	-4.400	1	.000	0.012				
HSPT	HSPT	0.023	1	.000	1.024	807.111	537.413*	0.552	82.8%
	Constant	-10.978	1	.000	0.000				
Rec	Rec	2.751	1	.000	15.658	1011.770	332.755*	0.374	75.8%
	Constant	-0.347	1	.000	0.707				
Acuity/HSPT	Acuity	0.196	1	.000	1.216	744.515	600.009**	0.600	84.7%
	HSPT	0.017	1	.000	1.017				
	Constant	-10.470	1	.000	0.000				
Acuity/Rec	Acuity	0.278	1	.000	1.321	833.532	510.992**	0.531	80.7%
	Rec	1.322	1	.000	3.750				
	Constant	-3.869	1	.000	0.021				
HSPT/Rec	HSPT	0.020	1	.000	1.020	757.519	587.005**	0.591	83.6%
	Rec	1.429	1	.000	4.176				
	Constant	-9.707	1	.000	0.000				
Acuity/HSPT/Rec	Acuity	0.154	1	.000	1.166	725.029	619.496***	0.615	84.2%
	HSPT	0.016	1	.000	1.106				
	Rec	0.985	1	.000	2.677				
	Constant	-9.719	1	.000	0.000				

Note: *df = 1, $p < 0.001$; ***df* = 2, $p<0.001$; ****df* = 3, $p < 0.001$ (from Omnibus Test of Model Coefficients)

Table 3
BLR Analyses for Different Combinations of Placement Criteria (ACT ≥ 29)

	Predictor	*β*	*df*	*p*	*Odds Ratio*	*-2 Log Likelihood*	X^2	*Nagelkerke* R^2	*Predictive Accuracy*
Null Model						1224.115			73.9%
Acuity	Acuity	0.339	1	.000	1.403	762.469	461.646*	0.515	83.5%
	Constant	-7.381	1	.000	0.001				
HSPT	HSPT	0.022	1	.000	1.023	759.915	464.200*	0.517	84.2%
	Constant	-13.571	1	.000	0.000				
Rec	Rec	2.894	1	.000	18.072	953.422	270.693*	0.328	73.9%
	Constant	-3.057	1	.000	0.047				
Acuity/HSPT	Acuity	0.208	1	.000	1.231	686.004	538.111**	0.580	86.2%
	HSPT	0.014	1	.000	1.014				
	Constant	-12.731	1	.000	0.000				
Acuity/Rec	Acuity	0.288	1	.000	1.334	742.994	481.121**	0.532	83.9%
	Rec	1.130	1	.000	3.097				
	Constant	-7.249	1	.000	0.001				
HSPT/Rec	HSPT	0.019	1	.000	1.019	724.802	499.313**	0.548	84.6%
	Rec	1.434	1	.000	4.197				
	Constant	-12.649	1	.000	0.000				
Acuity/HSPT/Rec	Acuity	0.180	1	.000	1.197	678.093	546.022***	0.587	85.8%
	HSPT	0.013	1	.000	1.013				
	Rec	0.772	1	.006	2.163				
	Constant	-12.324	1	.000	0.000				

Note: *df = 1, $p < 0.001$; **df = 2, $p < 0.001$; ***df=3, $p < 0.001$ (from Omnibus Test of Model Coefficients)

Table 4

BLR Analyses for Different Combinations of Placement Criteria (ACT ≥ 32)

	Predictor	*β*	*df*	*p*	*Odds Ratio*	-2 Log Likelihood	X^2	*Nagelkerke* R^2	*Predictive Accuracy*
Null Model						836.968			86.7%
Acuity	Acuity	0.316	1	.000	1.372	556.032	280.937*	0.426	89.3%
	Constant	-8.219	1	.000	0.000				
HSPT	HSPT	0.021	1	.000	1.021	539.613	297.356*	0.447	89.8%
	Constant	-14.049	1	.000	0.000				
Rec	Rec	2.998	1	.000	20.052	695.953	141.015*	0.228	86.7%
	Constant	-4.143	1	.000	0.016				
Acuity/HSPT	Acuity	0.180	1	.000	1.197	502.481	334.487**	0.495	89.9%
	HSPT	0.013	1	.000	1.014				
	Constant	-13.365	1	.000	0.000				
Acuity/Rec	Acuity	0.283	1	.000	1.327	549.633	287.336**	0.434	89.2%
	Rec	0.978	1	.019	2.659				
	Constant	-8.330	1	.000	0.000				
HSPT/Rec	HSPT	0.018	1	.000	1.019	527.193	309.775***	0.464	90.3%
	Rec	1.291	1	.002	3.637				
	Constant	-13.704	1	.000	0.000				
Acuity/HSPT/Rec	Acuity	0.163	1	.000	1.177	500.347	336.622***	0.498	89.8%
	HSPT	0.013	1	.000	1.013				
	Rec	0.608	1	.160	1.838				
	Constant	-13.306	1	.000	0.000				

Note: **df* = 1, $p < 0.001$; ***df* = 2, $p < 0.001$; ****df* = 3, $p < 0.001$ (from Omnibus Test of Model Coefficients)

Table 5

Predictive Accuracy: Base Models vs. Predictor Models

	ACT = 24	ACT = 29	ACT = 32
Base Model	67.6%	73.9%	86.7%
Individual Predictor – Average	79.6% (+12.0)	80.5% (+6.6)	88.6% (+1.9)
Multiple Predictor – Average	83.3% (+15.7)	85.1% (+11.2)	89.8% (+3.1)