College Math Performance and Last High School Math Course

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ABSTRACT

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Only half of high school graduates take math during their senior year (Perkins, 2004) with just 18% going beyond Algebra II (Adelmen, 1999), while mathematics faculty at a large research university report poor performance in college level coursework. This study examines performance in first college math core courses in relation to time since last high school math course and level of high school math taken. Analysis assesses whether high school math GPA improves prediction of college core math grades in comparison to an institution-designed college math placement test, for all students as well as for a high risk group. The high risk group consists of students either not taking math their senior year in high school and/or not going beyond Algebra II. Findings have implications for advising, predicting college success and providing feedback to high schools.

Acknowledgement

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COLLEGE MATH PERFORMANCE AND LAST HIGH SCHOOL MATH COURSE

I. INTRODUCTION

Extending a recent high school transcript study conducted by the National Center for Educational Statistics (Perkins, 2004), an office of institutional research investigated the impact of time since last high school math course and level of high school math course taken on college math performance of entering freshmen. Preliminary results, examining core course performance at a major research university, raised concern over failure rate in math core courses and low math placement test scores. Thirty-two percent of entering freshmen enrolling during the 2001-02 and 2002-03 academic years received either a grade of D or F (16% F) in their first math course. Of additional concern was the average score (11 out of 25) on a locally-designed math placement test. Further examination, of performance in all math core courses, showed that 21% of the population received a grade of F. This math core failure rate was much higher than that for core courses in all areas (10%). Additionally, for math core courses, there was only a weak correlation (.23, p< .01) between the math placement test scores and core math grades, explaining only 5% of variance in performance.

Looking beyond the significance of these institution-specific findings, national statistics suggest that time since last high school math course may be a significant contributing factor in poor math performance. The National Center for Education Statistics (Perkins, 2004) reports that only half of graduating high school seniors take math their senior year, but these students outperform others completing math in earlier years, when measured on a math assessment test. Additionally, only 18.4% of all graduating seniors (23.6% for college bound seniors) go beyond Algebra II (Adelman, 1999). These national and regional findings lead to the following questions: Is time since last high school math course and the level of math course taken in high school contributing to poor performance on a locally designed math placement test? Would a math high school GPA serve as a more effective predictor of math core course performance over the math placement test? Is there a new generation of high school graduates at risk for poor college math performance? The feedback from these results is critical to both high schools preparing future college freshmen and faculty attempting to assess their methods of student placement.
II. LITERATURE REVIEW

For over 20 years there has been a push for high school curriculum reform nationwide. Despite multiple efforts to align high school preparation with college standards, recent studies show that more students are entering college less prepared than ever (Crist, Jacquart & Shupe, 2002). A study for the U.S. Department of Education’s Office of Vocational and Adult Education showed that while fewer than 70% of Minnesota high school graduates completed the recommended coursework for state universities, 80% of the students enrolled immediately upon graduation. Similarly, only 35.7% of students graduating high school in California in 1999 had completed a college preparatory curriculum (California State Postsecondary Education Commission, 2001), and a study in Maryland showed that over half of all students who began college immediately after high school in 1999 needed to complete remedial work in English, math or reading, if not all three (Keller, 2001). With students evidently behind in academic groundwork, what is the source or cause of this lack of preparation?

The senior year of high school is the key to academic success throughout college according to the National Commission on the High School Senior Year (NCHSSY, 2001). Far too often, as described by this Commission (NCHSSY, 2001, pg. 11), a student’s final year of high school becomes a “lost opportunity” as he or she treats the year as a “rest stop” in his or her academic career instead of as a “launching pad” to prepare for the rigorous coursework required in a post-secondary education (NCHSSY, 2001, pg. 11). High school seniors view their final year as an opportunity to take less demanding classes and enjoy non-academic pursuits (Kirst, 2001). According to Kirst, the education system itself is the cause for the “Senior Slump.” State assessments of K-12 education end in the 10th or 11th grade year, college admissions calendars make senior year classes inconsequential in admissions decisions, and there is no link or coordination between high school graduation requirements and college admissions requirements (Kirst, 2001). With so much emphasis in high school placed on college admission and not on college preparation, a larger number of students are beginning college but only 51% of them are graduating within five years of initial enrollment (ACT, November 2002). The Director of ACT’s Office for the Enhancement of Education Practices believes that the declining graduation rate from universities (3.5 percentage points from 1991 to 2001) should not be viewed as discouraging, considering that enrollment rates are rising, increasing the likelihood that some of these students will be less prepared. Like many others in the education field, he also feels that
transition to college is difficult for most students, but particularly for those with limited academic skills (ACT, November 2002).

Accepting the widespread idea that students are generally not prepared for college coursework, many studies have turned to identifying which influences result in college achievement and have found a link between high school math courses completed and post-secondary academic success (Ruban & Nora, 2002; Kirst, 2001; Bottoms & Feagin, 2003; Keller, 2001; U. S. Department of Education, 1997; Adelman, 1999; Perkins, 2004). A 1999 study from the U.S. Department of Education found that taking a math course beyond Algebra II in high school more than doubled a student’s likelihood of completing a bachelor’s degree. As the highest level of secondary math rose, the likelihood of degree attainment followed, culminating with more than 80% of students who took calculus receiving a degree (Adelman, 1999). Other analyses concluded that students who took calculus were 28 times more likely to be a “high achiever” in post-secondary work, and that the level of math taken, regardless of factors such as race, socio-economic status, or type of high school, was the largest indicator of college achievement level (Ruban & Nora, 2002; U. S. Department of Education, 1997). A high school transcript study conducted by the National Center for Education Statistics found a link between scores on a mathematics assessment test and the length of time since a student’s last math course. Scores were highest for students who had their last earned math credit in the 12th grade, followed by students whose last coursework was in the 11th grade. The lowest scores were by those who had not taken math since their 10th grade year (Perkins, 2004).

With fewer than 40% of high school graduates completing four or more years of math, and the typical high school requiring only three for graduation, the implications for students’ futures are harsh (ACT, February 2002). Students are unaware of the impact high school coursework can have on their degree attainment. Twenty percent of students taking the ACT in 2002 indicated that they wished to pursue a career in the health sciences, majors that are full of upper-level math courses. Only 32% of those same students received an ACT Math sub-score at or above 27, the level ACT acknowledges as being ready for college calculus. What many students do not foresee is that the preparatory work they will have to complete before taking the required courses for their degree will often discourage them and result in their changing majors to ones not requiring extensive math or dropping out of college completely, and that limited math work in high school can severely restrict their career choices (ACT, February 2002; Waits & Demana, 1988). Further, students’ exposure to challenging math courses enhances self-regulatory skills that benefit
achievement in all courses attempted in post-secondary education (Matthews, 2000), and challenging high school courses, regardless of the grade earned, prepare students for the learning environment of college and enhance their ability to succeed in upper-level classes. (Matthews, 2000; Adelman, 1999). However, there is evidence that only a small proportion of high school seniors (18.4% of all seniors; 23.6% of all college bound seniors) go beyond Algebra II, limiting their exposure to challenging math (Adelman, 1999).

III. THEORETICAL FRAMEWORK

There is evidence showing math self-efficacy to be the best predictor of college math performance (Bourquin, 1999). Self-efficacy can be described as going beyond possessing certain skill sets to belief as to what one can do with those skills under varying circumstances (Bandura, 1997). Past performance has been shown to be the best source of self-efficacy or perceived capabilities, yet time between assessment of self-efficacy and performance is important. The further away from past performance a student is, the less accurate their perceived self-efficacy may be (Luzzo, et. al, 1999). This leads to the hypothesis that freshmen not having taken math during their senior year may approach a college math placement test and possibly even college math courses with inaccurate perceived beliefs in math self-efficacy. While self-efficacy is not measured in this study, it provides the framework for examining the relationship between two measures of performance (high school and college math courses) and the impact of time. Past performance in high school math courses may not be related to performance on a locally designed college math placement test, because of the elapsed time of measurement. Likewise, past performance in high school math may not equally predict college math performance for two groups: those that take math their senior year and those that do not.

IV. RESEARCH QUESTIONS

With the knowledge that high school preparation significantly predicts success in college, the question then becomes where or at what level do students begin college math without substantial risk of failure? Does high school senior year math and level of high school math impact performance in college math? With math placements tests increasingly being used to determine beginning level of college math, another question arises: Do math placement tests effectively predict performance of students who did not take math during their senior year of high school or who do not go beyond Algebra II? The larger question for the designers of this
local math placement test becomes: Is placement working and is it necessary? Thus an academic unit teamed up with an institutional research office to examine these questions.

V. ANALYTICAL METHOD AND RESULTS

Method of inquiry included transcript analysis for freshmen beginning in the academic year 2001-02 who had graduated from high school during the preceding academic year. Data collected included the level of each math course taken in high school, as well as the last high school year in which students completed a math course. An average high school math GPA was calculated for each student. For this same group, grades received at this institution for the first math course taken, as well as ACT/SAT/math placement scores and demographics were compiled from the student information system.

To conduct the transcript analysis, a random sample (N=920) was taken of a freshman entering class (N=3,758). Of this sample, only 699 had final transcripts that could be used for the analysis. The final sample of almost 20% of entering freshmen closely matched demographic characteristics of the typical entering freshmen at this institution as well as other characteristics such as high school GPA and standardized test scores.

Hypotheses examined included:

1. There will be a significant difference in performance in first college math course taken for students identified as high risk (those not taking senior year math and/or not going beyond Algebra II) and the total sample population of new freshmen entering fall 2001, as measured by a single sample t-test.
2. There will be a significant difference in performance in first college math course taken for students who followed placement and those who did not follow math placement score as measured by a single sample t-test.
3. A locally designed math placement test will account for variance in performance in first college math course taken, over and above a high school math GPA.
4. A locally designed math placement test will account for less variance in performance in first math course taken over and above a high school math GPA for students identified as either not taking high school senior year math and/or not going beyond Algebra II.
**Hypothesis 1.**

Examining a summary of frequency distributions for both all students and the high risk group shows clear differences in performance in first math course (Table 1).

<table>
<thead>
<tr>
<th>Grade</th>
<th>High Risk Students (N=117)</th>
<th>Total Sample (N=699)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>20.0%</td>
<td>13.7%</td>
</tr>
<tr>
<td>D</td>
<td>22.9%</td>
<td>14.3%</td>
</tr>
<tr>
<td>C</td>
<td>24.8%</td>
<td>23.7%</td>
</tr>
<tr>
<td>B</td>
<td>20.0%</td>
<td>25.7%</td>
</tr>
<tr>
<td>A</td>
<td>12.4%</td>
<td>22.6%</td>
</tr>
<tr>
<td>D or F</td>
<td>42.9%</td>
<td>28.0%</td>
</tr>
<tr>
<td>Average Course GPA</td>
<td>1.86</td>
<td>2.29</td>
</tr>
</tbody>
</table>

Results showed a statistically significant difference in the average college math course GPA. A single sample t-test was used to determine if there was a significant difference in first math course performance (mean grade) for all students in the sample and the subset of the students in the identified high risk group. All assumptions of t-tests were met by examining normality plots and sampling procedures (Shavelson, 1988). For 117 observations there was a mean difference of -.4268 with a standard error of .12314, resulting in a t (2, 116) = -3.165 with, p <.01. For this population of high risk students, there is a significant difference in performance in first college math course with the high risk subgroup performing lower than the total sample population.

**Hypothesis 2.**

Examination of a summary of frequency distributions for both all students and those students who did not follow placement advice of a locally designed math placement test show differences in performance of first college math course (Table 2).
Results again showed a statistically significant difference in the average college math course GPA. A single sample t-test was used to determine if there was a significant difference in first math course performance (mean grade) for all students in the sample and a subset of students identified as not following placement advice (i.e., starting above the recommended level of beginning college math). All assumptions of t-tests were met by examining normality plots and sampling procedures (Shavelson, 1988). For 242 observations there was a mean difference of -.3992, with a standard error of .0408 resulting in a $t(2, 241) = -4.784$ with, $p < .01$. Thus, students not following the advice on math placement of a locally designed test performed lower in their first math course in comparison to the total student population.

**Hypothesis 3.**

Further analysis consisted of applying hierarchical multiple regression and correlation procedure to evaluate predictors of college math core course GPA, comparing the amount of variance accounted for by math high school GPA, and locally designed math placement test. The model was applied to two groups: 1) all entering freshmen in the sample, and 2) students who
completed math high school requirements prior to their senior year and/or did not take a higher level math. Model fit and variance explained were examined for the two groups. Assumptions of multiple regression were met. VIF Factors of 2.28 and 2.03 were low with acceptable tolerance values of .92 and .79. Due to multicollinearity or redundant relationships between ACT/SAT math sub-score and math placement test, standardized sub-scores were not examined in the regression model.

Correlation coefficients were first examined to determine the strength of the relationships between the independent and dependent variables. As suspected, the highest correlation occurred between the first college math grade and high school math GPA (.482, p<.01). The strength of this relationship exceeds that of the math placement test (.337, p<.01) and ACT-Math (.304, p<.01) and SAT-Quantitative (.327, p<.01) (Table 3).

<table>
<thead>
<tr>
<th>Predictor</th>
<th>N</th>
<th>Grade</th>
<th>GPA</th>
<th>HSGPA</th>
<th>AMATH</th>
<th>ACT-M</th>
<th>SAT-Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>699</td>
<td>---</td>
<td>0.482 *</td>
<td>0.451 *</td>
<td>0.337 *</td>
<td>0.304 *</td>
<td>0.327 *</td>
</tr>
<tr>
<td>Math GPA</td>
<td>699</td>
<td>0.482 *</td>
<td>---</td>
<td>0.775 *</td>
<td>0.462 *</td>
<td>0.470 *</td>
<td>0.445 *</td>
</tr>
<tr>
<td>HSGPA</td>
<td>699</td>
<td>0.451 *</td>
<td>0.775 *</td>
<td>---</td>
<td>0.415 *</td>
<td>0.403 *</td>
<td>0.339 *</td>
</tr>
<tr>
<td>AMATH</td>
<td>658</td>
<td>0.337 *</td>
<td>0.462 *</td>
<td>0.415 *</td>
<td>---</td>
<td>0.685 *</td>
<td>0.597 *</td>
</tr>
<tr>
<td>ACT-Math</td>
<td>579</td>
<td>0.304 *</td>
<td>0.470 *</td>
<td>0.403 *</td>
<td>0.685 *</td>
<td>---</td>
<td>0.823 *</td>
</tr>
<tr>
<td>SAT-Quantitative</td>
<td>296</td>
<td>0.327 *</td>
<td>0.445 *</td>
<td>0.339 *</td>
<td>0.597 *</td>
<td>0.823 *</td>
<td>---</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.01 level (2-tailed).

Model fit was examined for the total student population, showing the R² significant at .253 (p<.01) with an accompanying ANOVA, F (2, 265) = 111.18, p<.01. Both the high school GPA and math placement test accounted for 25% of the variance in first college math grades. The math
placement test significantly accounted for $R^2$ change of .016 beyond the effect of high school math GPA (Table 4).

**TABLE 4**

**COMPARISON OF MODELS**

**ALL STUDENTS AND SUBSET OF HIGH RISK STUDENTS**

<table>
<thead>
<tr>
<th>Model</th>
<th>$R^2$</th>
<th>F for $R^2$</th>
<th>Total $R^2$</th>
<th>$R^2$ Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Students</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictors:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>High School Math GPA</td>
<td>0.237</td>
<td>204.305 *</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Math Placement Test</td>
<td>0.016</td>
<td>14.010 *</td>
<td>0.253</td>
<td>---</td>
</tr>
<tr>
<td><strong>High Risk Students</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictors:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>High School Math GPA</td>
<td>0.188</td>
<td>23.865 *</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Math Placement Test</td>
<td>0.001</td>
<td>0.183</td>
<td>0.189</td>
<td>---</td>
</tr>
<tr>
<td>All Students Model and High Risk Students Model</td>
<td></td>
<td></td>
<td>0.064</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the 0.01 level

**Hypothesis 4.**

The strength of the relationships with the dependent variables and college math grades were reduced for the subset of high risk students, with math placement tests losing predictability, and ACT-Math (.336, p<.01) and SAT-Quantitative (.391, p<.01) and high school math GPA (.370, p<.01) retaining significant predictability (Table 5). Thus, time elapsed since last high school math classes may be impacting the math placement test performance when freshmen enter college. Additionally, the math placement test may be designed to measure higher level math skills.
VI. DISCUSSION

Students who do not take math during their senior year in high school or do not take higher levels of high school math may be at risk for below average performance in the first college math course at this institution. Many studies have shown similar results, linking high school math preparation to college success in general. While this study cannot attribute cause to poorer performance of these high risk students, it does show significant differences in performance. More than four in 10 (43%) of the high risk students made a D or an F in their first college math course. Additionally, for these high risk students, math placement tests may not be a good indicator of retained math skills.
This study also provides evidence that students who start beyond the recommended entry level math course for college, may not perform as well as most freshmen at this institution. Thirty-six percent of the group not following placement advice made a D or an F. Comparing this performance to the group that did follow placement advice shows a difference of 13 percentage points. Only 23% of students following placement advice made a D or an F. These results show that placement testing at this institution may be positively impacting initial math course performance, if followed.

However, there is evidence that other methods of math placement may be closely comparable to this locally designed math placement test. Calculating high school math GPA for entering students could provide similar predictions of college performance as evidenced by a fairly strong positive correlation with first college math grade (.482). However, requesting this information from high schools or from admissions staff of institutions may be cumbersome and slow down the admissions process. The math placement test provides some additional predictive power over and above the high school math GPA, indicating the need for measuring both skills retained and previous preparatory work. With high school grades making such a strong contribution to prediction of college math grades, there is a case for not enforcing math placement results in isolation.

The study leads one to question whether standardized test sub-scores may be equally effective as this math placement test in predicting college math course performance. ACT-Math and SAT-Quantitative and the locally designed math placement test showed a similar moderate relationship to performance in college math. While the design of this study failed to answer this question, due to issues of multicollinearity in regression, it is an important question for future studies due to the cost of administering math placement tests.

The study uncovered an even larger question. If a small percentage of this institution’s students fit into this high risk category (17%), what is causing the low math placement test performance? An important point for this institution is that almost 87% of entering freshmen may be taking math beyond Algebra II, in contrast to other studies showing that only 23.6% of college bound seniors go beyond Algebra II (Adelman, 1999). Yet math placement test performance is lacking. Perhaps in the midst of all the competition for college admission, high school students have been convinced of the need for higher level math courses but, for whatever reason, are not retaining the material. While being careful not to point fingers only in one direction, one has to question if students are being prepared to retain their math skills. Questions also might arise as to whether the
higher education institution’s math placement test or, indeed, the quality of its mathematics instruction might be lacking.

While not identifying all the reasons, these findings give a basis for increased interaction and discussion among high schools that prepare future students and the higher education professionals, who admit, place, teach and assess them. Most importantly for this institution, an institutional research office teamed up with faculty to produce meaningful and applied research specific to their campus. Future studies may be designed to investigate the impact of gender and ethnicity, level of each high school math course taken and level of college math courses taken. Additionally, the college math grades examined need to go beyond first math course completed and the model’s effectiveness at predicting success versus failure should be investigated. Although likely not feasible, a separate study concerning high school graduates’ attitudes toward mathematics and the types of advisement they receive could prove interesting.
References


