University First-Time-in-College Students' Mathematics Placement and Outcomes: Leadership Response to Local Data

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Data-driven decision making is a critical leadership skill. This study describes how leadership at a four-year university used extant data to improve student outcomes. The University identified the high rate of first-time-in-college (FTIC) student withdrawal/failure in initial algebra courses as having a detrimental effect on other student success metrics such as student retention and completion rates. The study was initiated to determine how analysis of extant student data could enable leaders to better understand the problem, identify ways in which university policies and/or practices could be modified to increase students' pass rates in their initial math courses, and ultimately result in improved student outcomes. Data from four cohorts of first time in college students were analyzed to better understand the effects of the university placement practices on student outcomes, and potentially identify students who may be at-risk of failure to provide early intervention. The initial results indicate under-placement of female students in lower math courses at a statistically significant level, and potential use of students' high school GPA as an early-warning indicator of failure. The study highlights the importance of leaders monitoring and analyzing local data to assess the impact of current policies and practices on student outcomes.

***Keywords**: data-driven decision making, leadership, mathematics courses, placement*

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One of the hallmarks of effective educational leadership is continuous process improvement to increase student success (Gill, Bordon, & Hallgren, 2014; Mandinach, 2012). Educational settings vary in many ways including, but not limited to, student composition and needs, instructors' experience and expertise, and local resources. Leadership decision-making and practice must adapt to individual institutional needs, and therefore, must be rooted in local information and data. This study describes how leadership at a four-year university used extant data in a data-driven decision making process to improve student outcomes.

The University identified the detrimental effect of first-time-in-college (FTIC) student withdrawal/failure in initial algebra courses on other student success metrics such as student retention and completion rates, which were considerably lower than for other campuses in the regional system. This study was initiated to determine how analysis of extant student data could enable leaders to better understand the problem, identify ways in which university policies and/or practices could be modified to increase students' pass rates in their initial math courses, and ultimately result in improved student outcomes. It builds on research regarding difficulties in accurate FTIC math placement primarily at the community college level (Bracco et al., 2014; Burdman, 2011; Hodara & Cox, 2016; Jaggars & Hodara, 2013; Scott-Clayton, Crosta, & Belfield, 2014).), and research on the use of early warning indicators of failure for early intervention in K-12 schools (Allensworth & Easton, 2007; DePaoli et al., 2015; Hartman, Wilkins, Gregory, Gould, & D'Souza, 2011). In addition to improving FTIC student success, this study was also intended to provide an example of a four-year university analysis of extant data to inform policies and practices.

Literature Review

College and career readiness has been a major focus in K-12 education for the last decade. One of the goals of the federal initiative Race to the Top (2009) was that all high school students graduate prepared to be successful in college and careers. However, the rigor of K-12 curriculum standards vary across states, as do high school graduation requirements (Tepe, 2014). Different organizations describe college readiness from various perspectives resulting in dissimilar definitions (Rolfhus, Decker, Brite, & Gregory, 2010). Postsecondary institutions' entrance requirements vary, as do the students' skill competency requirements for entry-level courses (Tepe, 2014). These varying standards and requirements can make the transition from high school to college challenging, especially for less-prepared students (Scott-Clayton et al., 2014; Venezia, Kirst, & Antonio, 2003; Wilkins, Hartman, Howland, & Sharma, 2010).

College Math Placement Practices

Given that students have such different levels of preparation, identifying the best initial college courses for students to take is an inexact science. The goal is to place students in the highest courses in which they are likely to succeed, but avoid enrolling them in courses for which they do not have adequate prerequisite skills (Scott-Clayton et al., 2014). Numerous studies have examined the accuracy of different placement criteria, as well as the outcomes for students placed in both remedial and credit-bearing courses, particularly at the community college level because of their more open admissions policies and the high percentage of students required to enroll in developmental (remedial) courses (Bracco et al., 2014; Hartman, 2017; Hodara, Smith-Jaggers, & Karp, 2012; Hughes & Scott Clayton, 2011; Scott-Clayton, 2012). Standardized test scores,

specifically the SAT and ACT, are most commonly used for placing FTIC students in English and math courses because most take one of these tests as part of their college application process, and the scores are readily accessible to institutions of higher education. This practice is important to note particularly as it relates to math because numerous studies report that overall, males consistently outperform females on the mathematics portions of standardized tests (Beekman & Ober, 2015; Combs et al., 2010). Since 1972, females have consistently scored significantly lower on the SAT-M than males (College Board, 2016). The accuracy of using these standardized tests for initial course placement has been called into question because of the potential gender bias, and the lack of correlation between scores and college achievement (Dorner & Hutton, 2002; Hartman, 2017). One community college study indicates that using these test scores for placement results in misplacing as many as 25% of students in initial courses (Scott-Clayton et al., 2014). Most of the misplacements are instances in which students are placed in courses lower than they were likely to be able to take and pass (based on other variables), also known as 'under-placement'.

Given that universities have a variety of selection criteria for admissions, it is valid to consider whether the same biases and/or misplacement decisions are prevalent in those institutions. While it is important for educational leaders to be aware of national trends, it is equally important for them to know the profile and trends for the specific student population at their institutions, carefully monitor the effects of using specific criteria on related student achievement and outcomes, and make informed decisions to promote student success (Mandinach, 2012).

Student Remediation and Support

In addition to more accurate course placement practices, supporting and retaining students in mathematics courses has also been a concern for post-secondary institutions. When it appears students do not have the prerequisite skills for specific entry-level courses, many postsecondary institutions enroll students in remedial courses to acquire the needed skills. However, these courses do not contribute credits toward students' degrees, and time and money is spent on courses that delay students' goal attainment (Bettinger & Long, 2005; Hughes & Scott-Clayton, 2011; Scott-Clayton et al., 2014). Postsecondary math achievement and success has presented a challenge for many students, and more students take remedial math courses than take remedial English courses (Bailey, Jeong, & Cho, 2010).

Studies have shown that, even when controlling for prior mathematics achievement, students who take remedial courses have lower completion/graduation rates (Adelman, 2004, 2006). In fact, a recent analysis of math course-taking in Florida colleges revealed that students who took remedial math courses did no better in completing credit bearing courses, and in some cases, fared more poorly (Park, Woods, Hu, Bertrand Jones, & Tandberg, 2018). These findings call into question the value of remedial courses and have renewed interest in identifying other strategies for supporting students who may not be prepared to take college math courses.

Support strategies, such as implementing summer boot camps to build prerequisite skills and concurrent enrollment in intensive support courses, have been implemented by institutions to improve student success (Hodara, 2013). Individual student support can be helpful, but often relies on student initiative and may not be sought or provided until the student has already fallen behind in or failed course work (Math Instructor, personal communication, March 28, 2016). Efforts to increase high school graduation rates over the last fifteen years have led many school districts to develop early-warning indicators of students likely to fail or drop out.

Considerable research has examined the effectiveness of using early-warning indicators in K-12 education to identify students who are at-risk of not succeeding, particularly across school transitions (as early as 6th and 9th grades) (Allensworth & Easton, 2007; Balfanz, Herzog, & Mac Iver, 2007; DePaoli et al., 2015; Hartman, Wilkins, Gregory, Gould, & D'Souza, 2011). These studies have documented the importance of early, accurate identification of students who are likely to dropout or not graduate from high school, and intervene in time to get students back on track to success. Similar efforts to identify students, who may be likely to fall behind or fail their college entry-level math course, and provide early supports and interventions may help improve student success. In summary, the challenge for improving university math success is two-fold – first, to improve the accuracy of placing students in the highest entry-level math course in which they are likely to succeed, and second, to identify students at-risk of failing and provide effective early intervention and support to keep them enrolled and ultimately successful.

Specific University Placement and Support Practices

Four-year institutions of higher education typically have admission requirements that imply only prepared students are admitted. Yet, university students still struggle with math requirements, and the university is perhaps less focused on supporting the developmental needs of students than at the community college level. Nationally, algebra is considered a gate-keeper course across organizations.

While it is useful to understand national trends, it is critical to understand the specific concerns and conditions in any given institution to be able to identify areas for improvement. The University in this study was a regional four-year institution serving approximately 5000 students with a wide range of undergraduate and graduate programs of study in west central Florida. As such it had a different FTIC population profile than most community colleges, and therefore, it was important to examine the University-specific student data regarding FTIC math placement and success. At the time of the study, the FTIC student population was approximately 64% female and 36% male, and the University math placement practice (policy) used solely ACT and SAT-M scores to place students in their initial math courses. While the University did not offer remedial courses, students whose prior math achievement did not appear to be adequate to enroll and be successful in College Algebra (MAC 1105 - the entry level credit-bearing course that met the math requirement for degree attainment) were enrolled in Intermediate Algebra (MAT 1033 - an entry-level math course, which could count as elective credit, but did not meet the math requirement for degree attainment). The University criteria for placing students in their initial mathematics courses (for the two courses examined in this study) were as follows:

- ACT – Students with an ACT score of 21 or above were enrolled in MAC 1105 (credit bearing); students with an ACT score of less than 21 were enrolled in MAT 1033.
- SAT-M - – Students with a SAT math score of 490 or above were enrolled in MAC 1105 (credit bearing); students with a SAT math score of less than 490 were enrolled in MAT 1033.

As described earlier, using prior math achievement data and/or placement tests to accurately place students in courses where they will be successful is an inexact science, and often students need additional support to succeed. While the University had a student support center, it relied on students to self-identify the need for academic assistance. In the fall 2016 semester, the University also began implementing an intervention support system for students who initially

struggle in math and English courses, but it relied on data that students were falling behind or failing several weeks into the course, which was often too late to recover and pass the course.

Student retention and completion rates at this University campus had been at least 10% lower than those on the University main campus (University X, 2016). Mathematics course-taking and success had been a particular focus for improvement. The first objective of this study was to examine the math placement policies, practices, and impacts on FTIC students at the University and to identify changes to improve student outcomes. The second objective of the study was to identify characteristics of students likely to struggle in their math courses and then provide support before students begin to fail. Accurately identifying students who were likely to need additional support as they began college coursework was an area that had potential for improving student retention and degree attainment. The results of this study contributed to achieving both of these goals.

Because the University served a different population of students than community colleges in general, and there were significant concerns about low retention and graduation rates, this study examined FTIC student math placement and success to evaluate and inform existing placement policies and practices. Extant data were analyzed to determine the relationship between criteria used for placement recommendation, course enrollment, and subsequent student success (passing a credit-bearing math course and subsequent year-two (Y2) retention) at the University. The analyses also informed the potential use of specific indicators to identify at-risk students for early additional math support.

The research questions for this study were:

1. What is the relationship between each recommendation criterion (ACT and SAT-M scores) and subsequent enrollment in entry-level math courses MAT 1033 and MAC 1105?
2. What is the relationship between each recommendation criterion and subsequent success (passing grade and Y2 retention) for students in entry-level math courses MAT 1033 and MAC 1105?
3. What is the relationship between students' high school grade point average (GPA) and subsequent success (passing grade) in entry-level math courses?
4. What is the pass rate for students who:
    1. qualified to take MAC 1105, but who enrolled in MAT 1033 instead?
    2. were recommended to take MAT 1033, but who enrolled in MAC 1105 instead?

Conceptual Framework

This study presents an example of analyzing extant student data to better understand the FTIC students' high failure rate in initial math courses at a specific institution, and as a result, identify potential modifications to the placement practices and use of early warning indicators to improve student success. The conceptual framework for data-driven decision making (DDDM) proposed by Mandinach (2012) guided this study. She defines a systematic, iterative process of using six skills at three different levels for using data to improve student outcomes. At the data level, practitioners collect and organize raw data relevant to the issue they are seeking to better understand. At the second level, the information level, they analyze the data for trends in participation or performance and then summarize the information by student groups. At the third level, the information is transformed to the knowledge level by synthesizing and prioritizing what these analyses mean, and used to make practice-related decisions to improve outcomes. The

researchers hypothesized that extant data the university collected during the students' application and enrollment processes could be used to better understand and address the FTIC students' high failure rate in initial math courses.

Methodology

Participants

The subjects in the study were FTIC University students enrolled in the 2011, 2012, 2013, and 2014 cohorts who had graduated from high school within the previous two years, and enrolled in either the intermediate algebra (MAT 1033) or college algebra (MAC 1105) courses their first year (approximately 1400 students). University individual student math achievement data (course passing), as well as transcript data (ACT, SAT-M, high school GPA) and demographic data were collected and analyzed.

Procedures

Overall, the analysis examined correlations between students' prior academic achievement variables and subsequent math course placement and success or failure. Data were also disaggregated by gender to determine whether there were significant differences on the basis of this demographic variable. The following extant data were requested for each FTIC student from the university Office of Institutional Effectiveness (OIE): gender, prior academic achievement and assessments (ACT and SAT-M scores), initial math course placement, final grade, subsequent math course placements and grades, retention to second year, and subsequent graduation date. Data were analyzed for correlations between criteria used for math course placement, high school GPA, math course success (passing grade), Y2 retention, and gender.

Students were separated by the FTIC math course in which they were enrolled. Correlation statistics using the recommendation criterion as the dependent variable and the success outcomes (initial course success, subsequent year two university enrollment) as the independent variables, were calculated for each recommendation criterion, and high school GPA. Recommendation criteria that indicated high correlations with student failure were identified for use as potential early-warning indicators to identify FTIC students who were likely to need additional support to be successful. Finally, students were separated by those who enrolled in a recommended course and those who did not, with descriptive statistics calculated to assess student success in the courses taken.

Findings

The initial analyses of the four cohorts of University FTIC students indicated several noteworthy findings regarding the University placement policies and practices, other useful achievement data such as high school GPA, and student placement in credit-bearing versus non-credit bearing math courses, particularly as it related to gender differences. These results informed the University placement practices and at-risk identification to improve student success.

Relationship between Placement Criteria and Initial Math Course Placement

Research question #1 focused on the relationship between each recommendation criterion and subsequent enrollment in MAT 1033 or MAC 1105. With some exceptions, the University ACT/SAT-M score guidelines were followed in placing students in their initial math courses. However, when examining enrollment by gender, there were notable differences. Table 1 indicates the proportion of female/male students in the FTIC cohort overall, and the proportion enrolled in MAT 1033 and MAC 1105. Proportionately, female students were overrepresented in the lower course (MAT 1033) and underrepresented in the higher course (MAC 1105).

Table 1

Proportion of Females and Males in FTIC Cohort Overall and MAT 1033/MAC 1105 Enrollment

	FTIC Cohort Overall	MAT 1033 Course	MAC 1105 Course
Female	62%	71%	58%
Male	38%	29%	41%

The over-representation of females in the MAT 1033 course could potentially be partially explained by the national trend of females generally scoring lower than males on standardized math tests. However, it is important to know, for this particular University FTIC student population, there was no statistically significant difference between males' and females' mean ACT or SAT-M scores. The general gender gap in standardized math scores would not account for the over-representation of females in the lower course (MAT 1033) at this particular University.

If, on the basis of her/his ACT/SAT-M score, a student was placed in a mathematics course higher than what s/he was qualified to take, the student was considered 'over-placed'. If, however, the student qualified to take the higher course, but enrolled in the lower course, the student was considered 'under-placed'. As shown in Table 2, a disproportionately high number of female students were under-placed into the MAT 1033 course, at a statistically significant level (p = -.0317). Too few students were over-placed in the MAC 1105 to make meaningful conclusions. However, it was worth noting more males were over-placed than females.

Table 2

Proportion of Students Who were Eligible to Take MAC 1105 but Enrolled in MAT 1033

	Eligible for MAC 1105 but Enrolled in MAT 1033	USFSP Cohort population
Proportion of Females	74.6%	62%
Proportion of Males	25.3%	38%

Note. X^2= 4.62; p = -.0317

Relationship between Placement Criteria and FTIC Math Course Grade

Research question #2 focused on the relationship between each recommendation criterion and subsequent success (passing the course). As shown in Table 3, statistical analyses for the study data set indicated there was no correlation between students' ACT or SAT-M scores and success (passing grade) in their FTIC math courses. The alpha level used as a significant criterion in this study was .05.

Table 3

Correlation between ACT and SAT Criteria and Math Course Score

	MAT 1033	MAC 1105
ACT Math and Course Score	$n = 257$	$n = 493$
	$r = 0.10$	$r = .007$
	$p = 0.10$	$p = 0.12$
SAT Math and Course Score	$n = 286$	$n = 574$
	$r = 0.01$	$r = .005$
	$p = 0.84$	$p = 0.26$

Math Course Final Grades by Gender

When analyzing final passing grades for the intermediate algebra course by gender, the data indicated the proportion of female students who earned passing grades in MAT 1033 was higher than males, at a statistically significant level ($p = .02$). When analyzing final passing grades for the college algebra course by gender, the data indicated that the proportion of female students who earned passing grades in MAC 1105 was higher than males, at a statistically significant level ($p = .012$; see Table 4). Additionally, Table 5 shows a higher proportion of female students earned an A- or higher in MAC 1105, though due to the small number of students, not at a statistically significant level ($p = 0.12$). The female students who took MAT 1033 and MAC 1105 were more successful than the males. This trend was consistent with national trends in terms of course grades.

Table 4

Proportion of Students Attaining MAC 1105 Passing Grades by Gender

	N	Proportion
Females	407	0.723
Males	274	0.631

Note. $p = 0.012$

Table 5

Proportion of Students Attaining A- or higher MAC 1105 Grades by Gender

	N	Proportion
Females	407	0.091
Males	274	0.058

Note. $p = 0.12$

Relationship between Placement Criteria and Y2 Retention

Since retention and graduation are the ultimate goals for FTIC students, the data analyses also examined the relationship between first-year math course enrollment and success, with year two university enrollment (persistence). For students who took either MAT 1033 or MAC 1105, the proportion of students who enrolled at the university in year two showed similar patterns. In terms of persistence by gender, there were no statistically significant differences for either course. Overall, the proportion of students who did not pass MAT 1033 or MAC 1105 and enrolled year two was lower than the proportion of students who passed MAT 1033 or MAC 1105 and enrolled year two, at a statistically significant level (MAT 1033 $p = .008$, MAC 1105 $p = .002$).

High School GPA Relationship to FTIC Math Course Success

Research question #3 focused on the relationship between students' high school GPA and subsequent success in entry-level math courses. Research has indicated that, in general, female students earn higher grades in high school and college courses than male students (Voyer & Voyer, 2005). In this University population, both for students enrolled in MAT 1033 and MAC 1105, the mean female student high school GPA was higher than the mean male GPA, at a statistically significant level, and reflects the national trends.

As shown in Table 6, there was a significant correlation between students' high school GPA and their success in FTIC math courses at this University. Specifically, students with a high school GPA of 3.0 or better were more likely to pass their FTIC math course. And even if the student's ACT/SAT-M course qualified her/him to enroll in MAC 1105, if her/his high school GPA was below 3.0, the student had less math course success.

Table 6

Correlation between High School GPA and Math Course Score

	MAT 1033	MAC 1105
High School GPA and Course Score	$n = 337$	$n = 675$
	$r = 0.32$	$r = 0.35$

Note. For both courses, $p < 0.001$

Course Success for Under Placed Students in MAT 1033 or Over Placed in MAC 1105

Research question #4 focused on math course success for those students who were under or over placed in their FTIC math course. There was no statistically significant difference in mean grades

between students who were under-placed in MAT 1033 and those who were 'correctly' placed on the basis of ACT/SATM scores, regardless of gender. A high proportion of females who were under-placed passed the course in comparison to males who were under-placed. There were too few students over placed in MAC 1105 to make any meaningful observations.

Conclusions

The analyses of extant local University mathematics data were informative for improving FTIC math course placement practices and subsequent student success. Although ACT/SAT-M scores were used exclusively for initial math course placement, there was no correlation between those scores and math course success. While expedient, the use of only ACT/SAT-M scores for placement purposes, and the possibility of significant numbers of students taking lower math courses than they are likely to be successful in as a result, was cause for concern. Refining University placement practices and specifically, using alternative, or additional criteria for placement, may be helpful to more accurately place students in credit-bearing math courses, and improve student outcomes. Several recent studies highlighting placement methodologies using multiple measures have been published and the university leadership examined the possibility of adopting similar systems (Barnett et al., 2018; Cullinan et al., 2018).

The under placement of FTIC female students (their ACT/SAT score qualified them to take 1105, but they took 1033) at a statistically significant level was important new information. These data findings were shared with University leadership, including the student advisement office. While it was not known from the study data collected whether student advisors had an impact on under-placement through their advisement practices, the data findings were shared with the advisors to heighten their awareness of the concern.

There was a statistically significant correlation between students' high school GPA and math course success. University leaders could use high school GPA as a factor to improve their math course placement system. In addition to considering GPA as a factor in the placement process, this information could be helpful for instructors to provide support for students whose high school GPA was below 3.0. Students who enter college with a high school GPA lower than 3.0, regardless of their ACT/SAT-M scores, may need additional support to succeed in their math courses. Low GPAs may also indicate the students need organizational or study skill support to supplement additional math support (Credé & Kuncel, 2008). Concurrent enrollment in a study support intervention may be helpful for these students.

In terms of Y2 retention, the high correlation of math course failure with non-retention was unsurprising because course failure results in non-credit accrual. It is important to note, however, that the analyses did not indicate math course failure was the reason students did not enroll for year two, rather it only established a relationship between passing the math courses and persisting to year two. Regardless, poor early math performance could be considered an indicator for identifying students who may need additional supports to persist.

Limitations

There were several limitations to the study. First, the study population consisted only of FTIC students who enrolled in a math course their first year. It did not include students who had been out of high school more than two years prior to enrolling in the University. The study population

also did not include FTIC students who did not enroll in a math course their first year. It is important to note all students in the 'freshman' class were not included in the study.

There are other math courses in which students may enroll, and these students were not included in these analyses. College Algebra (MAC 1105) is considered the 'gateway' course for higher mathematics required in most science-oriented majors. Only students enrolled in either MAC 1105 or MAT 1033 their first year were included in this study.

Finally, although four cohorts of students (N=1400) were studied, once multiple variables were included in the analyses, the number of subjects rapidly became too small to make meaningful conclusions. Subsequent data collection to include more cohorts would improve the power of additional analyses in this regard.

Recommendations

The findings in this study were unexpected by the University administration, and highlight the importance of leaders analyzing local data and examining the impact of policies as they are implemented locally to ensure unintended negative consequences are minimized. As student populations are dynamic, regular monitoring of student outcomes and data-driven decision making is a critical leadership practice. This study provided a positive example of data monitoring and analyses that can be applied to other institutional improvement efforts.

Further investigation of the causes of the disproportionate female under placement is recommended to improve female math success in particular. Additional investigation of the possible factors affecting female and male course enrollment decisions (such as mathematics confidence, prior mathematics experiences, prior external math supports) would be informative. FTIC female students outperformed males in both of the particular college mathematics courses in the study. Further investigation regarding the gender-related factors affecting student persistence (within each course), and success is also recommended.

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