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Research Article

High school transcript placement in developmental mathematics courses: A case study at one college

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ABSTRACT

Historically, college students who require remediation in mathematics have been placed into developmental mathematics courses. Accurate placement is important for student success; inaccurate placement in a low-level course could lengthen a students' time to degree completion. Placement policies have tended to focus on a high-stakes placement test, but more holistic approaches have been recommended. This study investigated success outcomes for students placed with a holistic approach of evaluating high school transcripts. Students who were placed into one of three developmental mathematics by their high school transcript at a suburban community college in North-eastern United States were selected for this study. A non-experimental, retrospective research study was conducted. Archival data of students who took a developmental mathematics course from fall 2015 through spring 2019 and had a high school transcript on file were chosen for this study. Findings from chi-square analyses indicated that high school transcripts that consider mathematics course grades are a viable placement option for developmental math courses, particularly the two lower-levels. However, lower than desired success rates suggest that placement is only the first step to increasing student achievement. A lack of high school transcripts suggests some students would prefer to take a placement test, particularly for students in the upper-level course on a college algebra path. A challenge for community college advisors will be creating an equitable placement policy for students who do not have a recent high school transcript.

Keywords: mathematics placement, high school transcripts, multiple measures, high school grade point average, success, persistence, developmental mathematics

INTRODUCTION

Developmental mathematics courses were created to help remediate post-secondary students who are not prepared for college-level mathematics. Historically, institutions of higher education have used a placement test to determine students' eligibility to enroll in specific developmental reading, writing, or mathematics courses (Bahr et al., 2019; Gerlaugh et al., 2007; Rose, 2012). These tests have tended to be either standardized multiple-choice tests from a commercial software developer or non-standardized tests developed by faculty members. In the latter case, faculty develop tests based on student learning outcomes. Placement tests are considered high-stake assessments because scores can alter students' paths to college completion. Holistic approaches to course placement provide an alternative to focusing on one test score and allow for a comprehensive placement approach that considers various aspects such as high school transcripts (HST), placement test scores, and non-cognitive assessments (Conley, 2010; Gerlaugh et al., 2007). In some instances, multiple measures might boost students into higher-level courses (Ngo & Kwon, 2014). A result

then could be a reduction in the number of students who are misplaced into remedial courses that may prolong their college education and impact their potential success and persistence (Bahr et al., 2019; Ngo et al., 2018). In this study, students were placed into developmental mathematics courses by an evaluation of their high school academic record that includes grade point average (GPA), course grade, and course selections. In this study, this evaluation of preparedness by academic record is referred to as HST placement. This study sought to examine differences in students' success and persistence rates by the courses they were placed in when the placement was conducted by HST.

Background of the Study

The predictive validity of placement scores has come under scrutiny, particularly as readiness has been defined differently at individual colleges. One college might find that a particular test score indicates college readiness while another may not. Furthermore, when other student variables are considered, the predictive validity of placement test scores as an indicator of college readiness remains unproven. For example, Belfield and Crosta (2012) found empirical evidence that high school GPA was a better placement measure than placement test scores. Evaluating HST can take more time for college administrators than evaluating one test score; however, HST might provide a picture of a student's academic work that indicates a broader range of knowledge in multiple attributes (Belfield & Crosta, 2012). Several studies found that using HST and GPAs placed students into college-level courses with strong academic success (Ngo & Kwon, 2014; Scott-Clayton, 2012). However, some faculty members have concerns about utilizing high school measures, which can include high school grade point average, mathematics high school grades, and diagnostic tools that provide information on students' abilities (Ngo et al., 2021).

Because placement is important and the use of multiple measures has been advocated, the community college in this study adopted and implemented a multiple criteria placement in mathematics. While this college did not follow a purely holistic placement approach, the college utilized multiple measures for placing students into mathematics courses. To place recent high school graduates (i.e., five years or less) in the highest possible college-level mathematics course, the participating college encouraged students to submit their HST prior to registration and at the start of their first semester. Students who had been out of high school for greater than five years or did not have their HST were encouraged to take the ACCUPLACER exam. Mathematics department faculty established placement criteria to place students from the lowest level of remediation (Math 020) up to and including calculus I. Advisors evaluated students' mathematics course placement at the time of registration. Placement decisions were made on the criterion that placed students in the highest mathematics course. In addition, to streamline the intake process, the college utilized mathematics course coordinators along with a math lab manager to field questions about developmental mathematics (DM) placement from students, faculty, and advisors. With varied measurements, questions that centered on student success and persistence by course level and placement policy, particularly regarding DM, remained unanswered. This study sought to find answers to some of those questions.

Statement of the Problem

Hughes and Scott-Clayton (2011) reported that "placement examination scores are commonly used not merely as a measure of skills, but rather as a high-stakes determinant of students' access to college-level courses" (p. 328). For many community college students, the exam is taken during orientation, and they are placed directly into a series of developmental education courses. The purpose of the placement test is to determine students' abilities and readiness to enroll in reading, English, and mathematics courses; yet students often take these high-stakes assessments without warning or preparation (Fay et al., 2013). Even when students schedule a test, they might not review the subject matter prior to taking the placement exam. Thus, students might not always understand the high-stakes nature of the test (Safran & Visher, 2010).

While many educators believe that the design of standardized exams should place students in a course that optimizes their probability of success, those tests might not always align with state or college-learning outcomes. For example, a generalized ACCUPLACER test may not address specific learning outcomes of a course, if the college has not tailored questions to meet those learning outcomes (College Board, 2018; Saxon & Morante, 2015). Other placement policies have included evaluation of HST that paint a broad picture of a

student, but those practices have been used less often and little research exists on the effectiveness of such placement practices.

Purpose of Study

This study investigated the success and persistence rates of students who were placed into developmental mathematics courses by their HST at one community college in North-eastern United States. This institution changed from solely relying on placement by commercial products to also including HST evaluations. With multiple research studies beginning to focus on multiple measurements (Hodara et al., 2012; Ngo & Kwan, 2014; Rutschow & Mayer, 2018; Scott-Clayton, 2012), there is a need for examining the relationship between course placement, student success, and mathematics persistence. Prior to this study, reporting of statistical findings regarding placement practices and students' success at the participating community college was not provided to faculty members. Instead, reporting was limited to total success in developmental courses (i.e., pass or not pass) with withdrawals not distinguished from failures; data were further disaggregated by ethnicity. Six years ago, the college redesigned its DM courses, which included creating common assessments, syllabi, and grading scales. This initiative has resulted in the ability to streamline data collection and assurance that learning objectives are being met. A goal of this study was to help administrators and educators make well-informed decisions. To fulfill this goal, student success rates and persistence in DM were compared to their course placement by HST placement.

Significance of Study

If failure rates in mathematics courses remain high and time to degree completion requires multiple DM courses for many students (Bahr, 2008), degree completion rates will not increase, and DM will remain a barrier for many students. Placement policies are important because they determine the point of entry in the mathematics course sequence and provide a measure of content readiness. Holistic approaches to placement consider students' overall academic background rather than focusing on one high-stakes placement exam. This study adds to the growing research on multiple placement measures by investigating a somewhat holistic placement approach for DM and the corresponding success and persistence of those students.

Retention and persistence are somewhat related terms. In post-secondary education, retention refers to the educational system keeping a student enrolled whereas persistence refers to students' individual ability to continue towards their goal. Both are important. For students to attain their degree, they must persist towards their goals. In order to do that, institutions must retain them. When students do not persist towards their educational goals, high attrition rates become a symbol of failure for institutions of higher education and the students they serve. As early as the 1970s, Tinto (1975) believed in the importance of integrating students academically and socially in the first semester. In Tinto's (1975) retention model theory, the integration of students into their college community through interactions with faculty, staff, and other students would more likely encourage students to stay and complete their coursework through to graduation compared to students who did not make those connections. Tinto's (1975) model of student integration evolved to include student motivation and goal commitments (Demetriou & Schmitz-Sciborski, 2011).

Tinto (2002) posits that access to college itself might be more fundamental to completion than a student's persistence. However, accurate course placement might also help students to succeed and, thus, persist. One of the ways colleges can increase the effectiveness of their placement policy is to give students responsibility for their level of preparation for their placement (Goeller, 2013; Koch et al., 2012). The involvement of both the college and the student implies that an action must occur. By increasing communication about the placement policy at an institution, both student satisfaction and retention can be increased along with efficiency.

Research Questions

Historically, many variations in placement have occurred at both two and four-year institutions of higher education. At this community college, the researchers sought to determine if there were differences in students' success and persistence rates by the courses they were placed in when placement was conducted by HST. The research questions were:

1. Are there statistically significant differences in students' success rates in Math 020, 022, and 026 when placed by HST?
2. Are there statistically significant differences in students' persistence rates in Math 020 and 026 when placed by HST?

Course Structure

Three levels of DM were offered during the 2015-2019 academic years. Each DM level could be taken as an emporium course, a face-to-face course, or an online course (i.e., Math 020, 022, 026). Math 020 did not require a prerequisite. Beginning in spring 2019, two sections of each level of mathematics were offered online, which was a decrease from the fall semester where three sections of each course were offered online. Two sections of intermediate algebra (Math 026) were not included in this study as they were offered in spring 2019 as co-requisite courses with college algebra (Math 140) and did not adhere to the same course structure or assessments. From fall 2015 through spring 2019, there were 128 sections of Math 020, 159 sections of Math 022, and 120 sections of Math 026 offered.

Each DM course used the same textbook and online homework platform. Common assessments in all course modalities included homework and quizzes that were delivered via a commercial internet program. Final exams were also common for all modalities. Exams were either completed via the commercial internet program or a Scan-Tron paper version so that question data could be tracked. On all common assessments, each problem was randomly selected from a set pool of items. This ensured that, while not all final exams, homework, or quizzes were identical, common learning objectives were tested. Starting in fall 2018, all exams became standardized and were utilized for online and face-to-face courses and were comprised of problems that came from the common chapter exams in the emporium classroom.

Courses were taught by both full-time and adjunct faculty. Emporium courses met in a lab-style classroom, where the instructor and two to three tutors worked in the designated course time, guiding students. Face-to-face courses consisted of one instructor, who may or may not have been in a computer classroom. As not all faculty had a computer room, students generally worked outside of the classroom on the course assignments. Those with computers took exams online and others took Scan-Tron paper exams in the classroom. Online students worked solely outside of a classroom environment. All online exams were mandated to be proctored, regardless of paper or computer format. Students in all modalities had limitations on testing aides. Students in the pre-algebra course were not allowed to use calculators but could utilize the common formula sheet. Students in elementary and intermediate algebra also could utilize the common formula sheet but were only allowed basic calculators for each exam.

Placement in Mathematics Courses at Community Colleges

Community colleges are open-access institutions with a diverse student population in regard to their academic preparation and reasons for attending. Many students from well-to-do families attend community colleges because these courses provide savings that can be applied to education beyond the bachelor's degree (Rose, 2012). For some students from lower economic status or rural areas, attending a two-year college might provide added support, particularly if they did not benefit "from high-performing schools or quality educational resources" (Rose, 2012, p. 9). Because many community college students might need an academic boost in their content knowledge (Chen & Simone, 2016), accurate placement has been necessary. In fact, one of the characteristics of a successful remediation program is the mandatory and early assessment and placement of students (Roueche & Baker, 1987; Roueche & Roueche, 1994). Determining placement into courses has been a standard part of the enrollment process (Gerlaugh et al., 2007). The academic course level a student may take depends on highly valued placement options (Bailey et al., 2010; Hughes & Scott-Clayton, 2011). While colleges frequently use measures like placement exams and Scholastic Aptitude Tests (SATs), HSTs have been used less often to make student course placement decisions (Gerlaugh et al., 2007). Research has been emerging about the effectiveness of multiple measures of prior mathematics, along with placement test scores, for accurate placement (Ngo & Kwon, 2014). Saxon and Morante (2015) suggest that a comprehensive model of assessment and placement would create a more accurate and refined process.

Placement exams

Oftentimes, students choose to take one attempt at a computerized, commercial placement exam that will determine

(a) if they will be required to enroll in developmental education courses and

(b) how many developmental education courses they will need to complete prior to enrolling in a college-level course.

In a survey of nationwide community colleges conducted by Gerlaugh et al. (2007), over 90% of institutions mandated a placement assessment. Of those surveyed, 97% were using ACCUPLACER created by the Educational Testing Service, and the majority used the SAT (Standardized Assessment Test) as another method of pre-screening. Hughes and Scott-Clayton (2011) reported that ACCUPLACER and COMPASS were among the most popular placement options. This allows assessment of multiple students at the same time and produces results quickly (Ngo & Kwon, 2014). There has been no uniformity on how each college determines the validity of the score and how it aligns with their learning outcomes. Only a handful of states around the country even conduct validity testing before using tests (Fulton, 2012). In a recent study in North Carolina, Hilgoe et al. (2016) found that students who passed the North Carolina Early Mathematics Placement Test finished with higher college GPAs than those students who failed the exam.

When a test is the only criterion used for course placement, cutoff scores are considered definitive; if a student is one point or 10 points above or below a cutoff score, the interpretation means the same in terms of placement (Belfield & Crosta, 2012). Validity of placement becomes complicated when students take placement exams without proper and adequate preparation. Reasons for the lack of preparation vary and include late enrollment, not knowing about the exam, or being unaware of the preparation materials available to them. (Fay et al., 2013). Camara (2013) notes that "in determining whether students are prepared or ready to succeed in college or career-training programs, direct evidence between test scores and performance in post-secondary education may provide the strongest form of evidence" (p. 16). Placement tests serve colleges in one of three ways:

(1) identifies deficiencies in content and preparation,

(2) certifies if a student is ready for college-level work, and

(3) identifies the correct course a student needs to enroll in (Camara, 2013).

Morante (2013) argues that placement exams could not predict a student's future success potential. Recent studies have shown some evidence that the predictive validity of these exams is low, with a weak correlation between students' pass rates and their placement scores (Belfield & Crosta, 2012; Ngo & Kwon, 2014; Scott-Clayton, 2012).

High school transcripts

According to Venezia et al. (2010), when there is a connection between the curriculum of the high school and community-college expectations, the evaluation of HST should be part of a holistic placement approach. A HST can provide information about a student's academic ability, effort, and college-readiness preparation courses that a single exam score cannot. As noted by Scott-Clayton (2012), HST might be more helpful at lower achievement scores because "they capture non-cognitive factors such as motivation and academic engagement that are particularly important in the lower tail of the grade distribution" (p. 16). Belfield and Crosta (2012) noted that HST can reveal cognitive competence, college-level readiness, and student effort. A challenge to the validity of the HST for course placement occurs when a course with the same name at different high schools covers different content. For example, pre-calculus might not include trigonometry at one school but might extensively cover it in another. Another validity challenge occurs when HSTs are not available. An analysis of placement of students at a large community college by Scott-Clayton (2021) revealed that 30% of the students did not have HST information available. Regardless of those challenges, HSTs hold promise for placement of recent high school graduates. Moreover, Scott-Clayton (2012) discovered that HST might more accurately predict student success at the college level.

Some colleges have used HST for placement purposes. For students who fail to achieve the required scores on SATs or ACCUPLACER exams, college officials at Montgomery College and Fredrick Community College in

Maryland look to HST. If students achieve a grade of B or higher in specific courses, they can enroll directly in the required college-level mathematics course (Matthews, 2015). In North Carolina's community college system, students with a high school GPA of 2.6 or higher and a minimum number of high school courses can bypass the placement exam altogether (Zinshteyn, 2016).

Placement Policy at Participating College

Historically, placement exams like the SAT or ACCUPLACER have been employed by colleges to determine whether remediation is required before college-level courses (Barnett et al., 2018; Gerlaugh et al., 2007). However, many problems occur when determining college readiness based on one placement test score, including students' lack of mental preparation to take the course and anxiety that arises from one score determining their academic trajectory (Cassady & Johnson, 2002; Fulton, 2016), as well as an inability to capture motivation and engagement (Scott-Clayton, 2012). Placing into lower-level DM coursework will prolong students' path toward their college degree and will increase their investment of time and money (Barnett et al., 2018). Encouragingly, since 2011, there has been an increase in the number of higher education institutions seeking to improve the placement of students using multiple measures rather than a single standardized exam (Rutschow & Mayer, 2018).

This study was conducted at a suburban community college that had a placement policy that has varied over time. For most of the history of the college, course placement occurred with a commercial software product called ACCUPLACER® created by the Educational Testing Service. Alignment of the college-learning outcomes with the commercial software never occurred; instead, scoring of student exams came from the publisher's recommendations. Students could also place into college algebra based on their SAT scores if submitted on time.

In 2015, the college moved to a placement policy that included utilizing HST criteria. The first step in creating the criteria was the formation of a committee that analyzed a variety of transcripts and then determined what the criteria would be for placement into a college-level course or one of the three developmental courses. Student mathematics placement was by

(1) ACCUPLACER scores,

(2) high school mathematics courses, grades, and GPA less than five years old (i.e., HST evaluation),

(3) prior college credits,

(4) self-placement, or

(5) SAT scores.

Course placement criterion at this community college placed students into the highest-level course, even if multiple placement criteria were available. In this study, placement options were not compared because some students had both ACCUPLACER and HST on file but there was no way to prove the order in which students decided to choose their placement option. In other words, a student could have sent in their HST but then decided to take the ACCUPLACER test. If the test was difficult, they could have given up on the test, which would have resulted in a low score, and decided to be placed by their HST. In that case, the ACCUPLACER test would not reflect their true knowledge.

This college placement committee understood that courses across high schools might not be equivalent. While high schools in the college's state followed a common core curriculum, no oversight occurred on what content was covered in each course. However, in the state the study was conducted, algebra I followed the state's end-of-course algebra exam, which all students had to pass to graduate. Any course higher than that could differ in content between schools. When evaluating SAT scores, students who received a score higher than 500 in mathematics were placed into college algebra. Scores on the SAT only applied for college algebra placement and, thus, were not included in this study. Students who had enrolled or completed a college mathematics course within the last five years were placed into the next respective college mathematics course, accordingly. For example, a student who took Math 020 at the college in spring 2015 would be placed in Math 022 in spring 2019.

College applicants who submitted their HST had their transcripts evaluated by staff in the student services division based on the students' completed mathematics courses along with their course grade and overall

Table 1. Placement coding policies per mathematics course

High school transcript (HST)	Math 020	Math 022	Math 026 or Liberal arts math	Math 026 but requires college algebra	College algebra & above
HST label 1 (GPA)	0	0	0 (GPA<3.0); 100 (GPA≥3.0)	100	100
100 (GPA≥3.0)	20	221	261/262	261/262	401/402; 601/602; 801

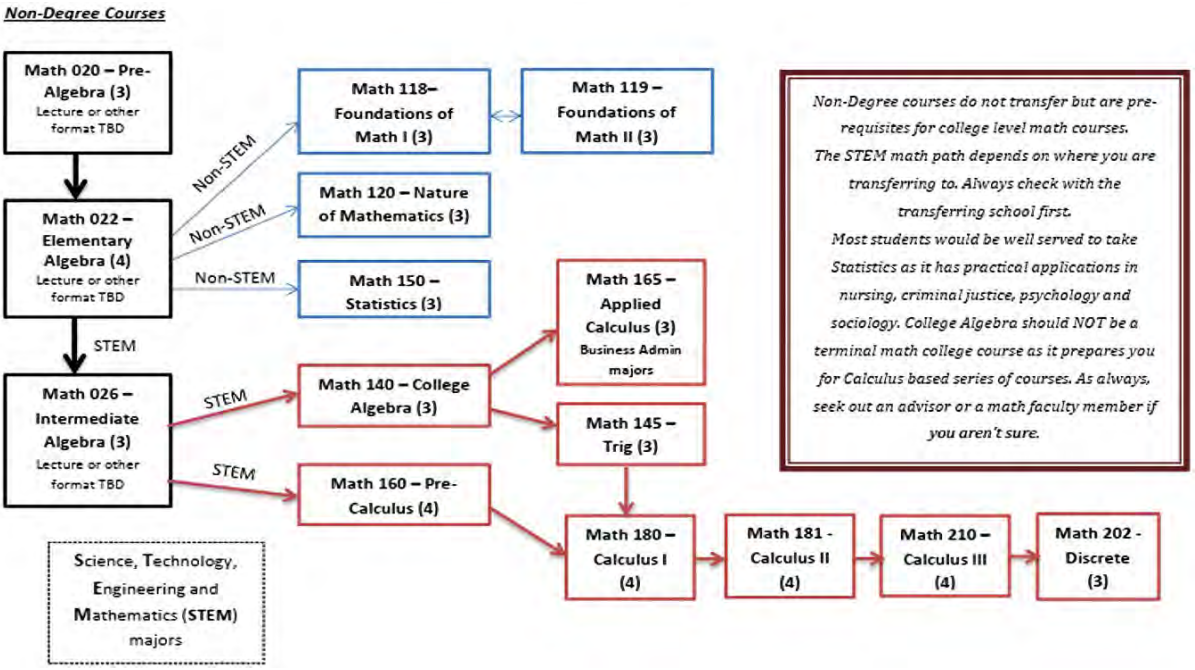

Figure 1. Mathematics placement chart

GPA. A student whose highest high school course was algebra I and who passed with a grade of C (73%) was placed in the lowest-level mathematics course, Math 020 pre-algebra. A student who completed pre-calculus or algebra III with trigonometry with a C or higher was given a score of 100 for GPA and 402 for math class. This designation placed them into college algebra at this community college. Once students began a DM course, they completed a diagnostic exam to confirm their placement. If a student scored an 80% or higher on this diagnostic, they met with their faculty member to discuss potentially moving ahead in the course sequence. Diagnostic exam scores were not tracked. **Table 1** lists the placement coding policies.

Figure 1 shows the progression through courses. For example, students who wish to major in computer science, but test into the lowest developmental mathematics course (Math 020), would have to take and pass Math 020, 022, 026, 140 & 145 or 160, 180, 181, 210, and 202 for a total of eight to nine semesters. While all developmental course grades count towards a student's GPA, course credits with a course identification of less than 100 did not fulfil degree requirements.

METHOD

This research design was a retrospective, nonexperimental study that used quantitative methods. A purposive and convenience sampling strategy was used. Enrollment data from fall 2015 through spring 2019 was analyzed.

Participants

The study used a purposive sampling strategy. All students who fit the following criteria were selected for the study: had a high school transcript on file, were placed into DM, and adhered to their placement criteria in DM courses (i.e., not enroll in a lower-level course). There were 2,217 students enrolled in Math 020, 2,214 enrolled in Math 022, and 1,253 enrolled in Math 026. The analysis sample size was smaller than enrollment numbers because of non-adherence to placement practices (i.e., student opted to take a lower-level course, chose to delay mathematics course enrollment, or left the college).

Table 2. Research questions for students who had a HST transcript on fi

Research question	DV	Data type	IV	Defined	Data type	Analysis
1. To what extent did differences exist between student success rates by course placement for students placed by the HST criteria?	Dev Math course grade (A to C (pass), C- to F (fail), W)	Cat	Course level	"1"=020; "2"=022; "3"=026; "4"=College ready (STEM & non-STEM)	Cat	Chi-square
				"1"=Math 020, "2"=Math 022, "3"=Math 026	Cat	
				"1"=Math 020, "2"=Math 022, "3"=Math 026	Cat	
2. To what extent did differences exist between persistence rates by course placement for students placed by the HST criteria?	Persistence ("0" passed & persisted, "1" persisted & failed/withdrew "2" not persisted & passed, "3" not persisted & failed/withdrew)	Cat	Course level	"1"=Math 020, "3"=Math 026	Cat	Chi-square

Note. DV: Dependent variable; Cat: Categorical; W: Withdrawal; & HST: High school transcript

Procedures and Research Design

Archival student data were retrieved from the Office of Institutional Research at this community college. The home institution generated new identification numbers (IDs) for each student to protect their identity. With the newly generated IDs, placement was identified and persistence of Math 020 and Math 026 students to their subsequent mathematics course was tracked.

Variables

Students could not continue to the next mathematics courses until they earned at least a C (73%) in their current DM course. Any grade less than a C required the student to repeat all or part of the course. Students could withdraw from any course at the college up to the end of the 14th week of the semester. Students who were withdrawn ("W") for lack of attendance were not differentiated in the college's system, and any "W" received by those students was considered a failure by the college, regardless of when that student received it. Grades were grouped as passing (A through C), failing (C- through F), and withdrawn (W). Students with an "I" on their transcript for an incomplete were considered failures because a change of grade was necessary to override a failing grade. Students with an "IP" for "in progress" received during spring of 2019 were counted for persistence, but then were removed as the current courses were not yet completed by the students; an IP only showed a willingness to continue to the next course. Because not all students received plus (+) or minus (-) grades, letter grades were collapsed. For example, a grade of B consisted of students who earned a B+, B, or B-. For the analyses, course placement for HST was coded as the following: "1"=Math 020, "2"=Math 022, and "3"=Math 026. Course success was in reference to the final remedial course grades and was coded as "0"=pass, "1"=fail, and "2"=withdraw.

Because not all Math 022 (elementary algebra) students were required to complete a mathematics course, the analysis for persistence was limited to students enrolled in the first and last DM courses (i.e., Math 020 and 026). Persistence data were generated by matching repeated student identification numbers. Persistence was then coded as a categorical variable to disaggregate persistence by passing or not passing the course. Persistence was coded as dichotomous and categorical. The dichotomous coding was "0" equals persisting and "1" equals not persisting. The categorical coding for persistence was as follows: "1"=passed the course and persisted to the next math course, "2"=failed or withdrew but retook the mathematics course, "3"=passed their course but did not take another mathematics course, and "4" failed or withdrew from their course and did not retake the course.

Data Analysis

Table 2 contains the variables, data type, and analysis for the two research questions disaggregated by placement criteria. Chi-square tests were conducted to test the null hypothesis that no differences existed for success and persistence by course level. Analyses were disaggregated by placement policy. The $p_{calculated}$ was compared to an alpha of .05.

Table 3. Student success disaggregated by course placement for students with a HST on file and total developmental mathematics population

	Students with an HST			Total college population		
Success measures	MATH 020	MATH 022	MATH 026[a]	MATH 020	MATH 022	MATH026[a]
	n=626	n=643	n=335	n=2,728	n=3,768	n=3,059
Passed	335	373	156	1,391	1,889	1,565
	53.50%	58.01%	46.57%	50.99%	50.13%	51.16%
Failed or withdrew	291	270	179	1,337	1,879	1,494
	46.49%	41.99%	53.43%	49.01%	49.87%	48.84%

Note. Total population includes the HST group

RESULTS

Research Question 1: Course-Level Placement by HST and Student Success

In accordance with recommendations in the literature, this study labelled Cramer's V effect sizes as small, medium, and large based on the degrees of freedom (see Kim, 2017). Of the 5,612 who were placed into a specific level of DM by their HST, 1,604 (28%) chose to adhere to HST placement by enrolling in the designated course (i.e., not enrolling in a lower course by choice or not in a higher course by ACCUPLACER placement).

Chi-square results indicated sufficient evidence to suggest differences existed at the α=.05 level between (a) course placement into DM courses by the HST criteria and (b) pass, fail, or withdraw grades for DM students, $\chi^2(6)=41.993$, $p<.001$, with no cells having an expected count of less than five and a small Cramer's V effect size of .077.

Table 3 also provides data on the entire college population. Comparisons of percentages suggest students placed by HST performed somewhat better than the total population for the lower two DM courses but not for the upper-level DM course. A Chi-square test was not conducted to compare the HST with the population because the independence assumption was violated (i.e., HST students also in the population of students).

Research Question 2: Course-Level Placement by HST and Persistence

All students enrolled in Math 020 and Math 026 were required to complete an additional mathematics course. For several degree programs, Math 022 could fulfill the mathematics requirement. As the degree information was not tracked, it was not possible to ascertain which Math 022 students required more mathematics courses. Therefore, analysis of persistence rates in this study was limited to students who were placed into either Math 020 or Math 026.

The results indicated that there was not sufficient evidence to suggest differences existed between (a) course-level placement by HST criteria into MATH 020 or MATH 026 and (b) persistence as measured by the dichotomous variable at the α=.05 level, $\chi^2(3)=7.626$, $p=.054$, albeit the small Cramer's V effect size of .060 suggests small differences might exist within the population. Students placed into Math 026 persisted 83% compared to almost 76% for Math 020 students.

There was sufficient evidence to suggest that differences existed between (a) course-level placement by high school criteria into MATH 020 or MATH 026 and (b) persistence as measured by the categorical variable at the p=.05 level, $\chi^2(9)=46.436$, $p<.001$, with a small Cramer's V effect size of .085. The percentage of students enrolled in Math 026 who persisted and passed was the same rate (41.5%) as the students who persisted and failed or withdrew. Those in Math 020 who persisted and passed did so at higher percentages than those who persisted and failed or withdrew.

Table 4 reports that students who adhered to their placement by HST evaluations tended to persist in mathematics (i.e., 75.7% in Math 020 and 83% in Math 026). There was no data to compare with the entire population, but it can conclude that students at this college who were placed in DM tended to persist to the next mathematics course.

Table 4. Persistence in mathematics disaggregated by course level

	High school transcript	
Persistence measures	MATH 020 (n=626)	MATH 026 (n=335)
Dichotomous		
Persisted	474 (75.7%)	278 (83.0%)
Not persisted	152 (24.3%)	57 (17.0%)
Categorical		
Passed & persisted	269 (43.1%)	139 (41.5%)
Failed/withdrew but persisted	205 (32.7%)	139 (41.5%)
Passed but not persisted	66 (10.5%)	17 (5.1%)
Failed/withdrew but not persisted	86 (13.7%)	40 (11.9%)

Note. HST were within the past five years

DISCUSSION

Accurate placement into mathematics is important to student success, but the best placement option has not been resolved (Belfield & Crosta, 2012; Ngo & Kwon, 2014; Rutschow & Mayer, 2018; Scott-Clayton, 2012). This study focuses on placement by HST, which can capture more about a students' academic background than a single placement test. Results indicated that, for students who were placed into DM courses by HST,

(a) DM students in the lower- and middle-level DM courses had slightly higher success rates than students in the upper-level course;

(b) compared to the total population of DM students, success was slightly higher in the lower- and middle-level DM courses and lower in the upper-level course; and

(c) persistence rates were high.

The findings in this study suggest that HSTs might be a viable placement choice to offer students, particularly for lower-level DM courses but placement by HST alone does not result in a substantial increase in success rates.

Student Success

Findings of this study support prior research claims that achievement in high school might serve as a viable placement alternative to standardized exams (see Belfield & Crosta, 2012; Ngo & Kwon, 2014; Scott-Clayton, 2012). Success rates by HST were higher in the lower- and middle-level DM courses; thus, HST placement appears to be a viable option. This supports findings by Scott-Clayton (2012) who noted that HST might serve better for those students because prior performance might capture non-cognitive factors (i.e., motivation or academic engagement). Socio-cognitive factors are important to success in DM courses (Zientek et al., 2019), and many DM students experience high levels of mathematics anxiety (Zientek et al., 2010). The proportion of students who provided a HST and were placed into the upper-level courses was lower, possibly because those students had other non-STEM college-level course options to take than 026 (i.e., statistics, math for elementary teachers, and quantitative literacy). Because student placement in college-level courses was not investigated, placement conclusions for HST should not be generalized to entry-level college courses. It is important to note that at this college HST evaluations were based on previous high school mathematics, grades in those courses, and overall GPA.

Persistence in Mathematics

Research on HSTs has tended to focus on grades. Scott-Clayton (2012) acknowledged that focusing on grades does not consider other important success outcomes, which include persistence. When persistence in mathematics was coded as persisted or did not persist, no statistically significant differences existed in persistence rates by course level when HST evaluations were utilized. Like student success, regardless of placement policy, some consistencies existed across the highest and lowest developmental courses in regard to persistence in mathematics. Students who adhered to their placement by HST evaluations tended to persist in mathematics, but it cannot be concluded that persistence was related to HST placement.

A Challenge of Placement by HST

While the use of HST was beneficial, this study also identified a challenge of utilizing HST which was also noted by Scott-Clayton (2012). What would you do with students who do not have a HST or who are returning after many years away from an educational setting? In Scott-Clayton's (2012) study, 30% of students did not have HST information on file. Similar to Scott-Clayton (2012), many students in this study (46.4%) did not have a HST on file that was less than five years. Of this 46.4%, 28.0% required Math 020, 19.2% required Math 022, and 22.4% required Math 026 or were non-STEM college ready. The remaining 30.4% of the 46.4% placed into a college-level course.

Recall that at the participating college it was the student's responsibility to provide their HST. A possible explanation for the lack of HSTs could be that students opted to take the placement test instead of proving an HST. For example, a student who was placed into a college-level course by a placement test probably did not decide to provide an HST. Students placed into DM courses might have also decided not to provide an HST. Offering alternative placement options makes it difficult to determine the viability of placement by HST, but the results suggest that a focus on HST will require early communication with students, preferably while students are still enrolled in high school. Furthermore, different placement options need to be in place for non-traditional returning students or for students who attained their General Educational Development Test (GED). Regardless, determining the success of placement options is further complicated when students delay their enrollment in mathematics courses (Lane et al., 2020; Zientek et al., 2022). Determining success in mathematics requires consideration of enrollment patterns.

Limitations

This study had several limitations. As this study was based on a single institution, the results might not be generalizable to other community colleges. This study was limited in its scope in that random assignment of students by placement was not possible. Furthermore, tracking of students' degree track was another limitation. This meant that persistence could not be measured for students enrolled in Math 022 (elementary algebra) because it was not possible to delineate the students in Math 022 who did not require additional mathematics requirements. For example, students who take Math 022 (elementary algebra) while pursuing a degree in the Licensed Practical Nursing degree program did not need additional mathematics. If included in the analysis, those students would have been categorized as not persisted when, in fact, they had completed their requirements and were a success by other measures. Furthermore, results in the upper-level course should not be generalized to the entire DM population because students in Math 026 were nursing intent or on a college algebra path. Finally, a limitation of this study was that the study only focused on students who were placed by HST in DM courses.

Implications and Future Research

Boatman and Long (2018) noted that attention needs to be given to determine accurate assessments of student placement in mathematics courses. This study contributes to the growing research on the success and persistence of students in DM courses based on HST evaluations that considered students' high school mathematics background and GPA. While evidence from this study suggests that prior high school achievement measures are a viable approach to placing students into their respective courses, particularly lower-level DM courses, HST is not a magical placement option that will result in high pass rates. Lower than desired success rates in this study suggest that placement alone is not going to lead to pervasive improvement in student success rates.

More research on comparing placement policies and student success and persistence needs to be conducted to determine the best placement practices for different types of colleges. Researchers need to be diligent in finding colleges that adhere to similar formats and cut off scores to compare student results. Information from this study can help advisors and instructors at this participating college improve their placement practices. Educators will need to explore alternative assessment measures for non-traditional students or students without a HST. Future research could be conducted to determine the applicability of HST with students who are placed in college-level courses. Furthermore, research should be conducted in upper-level DM courses that are comprised of students who are not entering a college algebra pathway.

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