HIGHER

Evaluating Math Placement Best Practices:

Multiple Measures and ALEKS PPL

McGraw-Hill Report

Executive Summary

Research suggests that the use of a single standardized placement test has led to many students who would have been successful in college-level courses being misplaced in developmental English and math courses. The multiple measures approach has become of interest because it attempts to use a combination of measures, such as high school GPA, last math class completed, standardized test scores, and standardized placement tests to achieve a more accurate placement process. While the multiple measures research for placement into college-level English is promising, placement into the appropriate college-level math class appears more challenging. There is a growing body of research showing that, unlike multiple measures or standardized placement tests alone, ALEKS Placement, Preparation, and Learning (PPL) used alongside multiple measures or as a standalone program can significantly increase student success across all math courses by identifying current math knowledge. This ensures accurate placement, and allows students to improve their placement by repairing prerequisite skills with a personalized learning path. ALEKS PPL narrows equity gaps by addressing the education debt resulting from differences in prior math opportunities and supports persistence in all pathways, regardless of the student's ethnicity, gender, age, or income.

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Introduction

Placement into the appropriate math course (and pathway) is the first step to a successful college career. Research shows that success in a student's first math course is the best predictor of degree attainment (Harrington, Lloyd, Smolinski, Shahin, & M., 2016) (Parker, 2005). Nationwide, millions of college students are incorrectly placed in math courses and then struggle to persist and complete their degree-required math courses. Students then lose time, money, and, often, confidence. Institutions and states also suffer with attrition costs and loss of state funding after failing to fulfill their mission. Placing students in the correct math course requires solutions on many levels, including new pedagogy, alternative pathways, and improved math placement processes—the focus of this paper.

Administrators, math educators, and policymakers have found the use of a single standardized math placement test is not predictive of course success and that students are often inaccurately placed into developmental courses, which do not count toward a degree. The hope is that with multiple measures, placement and success in college courses, as well as the rate of degree completion, will increase. "Multiple measures" uses a combination of metrics, such as high school GPA, last completed math class, standardized test scores, and a traditional placement assessment. The use of multiple measures has shown to increase the percent of students placing into and passing college-level courses, particularly in English. Research from a study in the State University of New York system (SUNY) showed that students placed with a multiple measure model were 30 percentage points more likely to be placed into college-level English, achieving a 40% enrollment and completion rate versus a 27% enrollment and completion rate when only a placement test score was used (Barnett, et al., 2018).

While the data for college-level English is promising, placement into the appropriate college-level math class appears more challenging. The SUNY study resulted in marginal gains in college-level placement in math—increasing from 44% to 49%—with the overall actual math course enrollment and completion rate improving slightly from 14% to 17% (Barnett, et al., 2018). The number of courses and pathways in the math sequence requires a more nuanced insight into student knowledge. Placement into the appropriate math course (and pathway) is the first step towards a successful college career. The ability to demonstrate productive persistence with a personalized learning path that repairs lost knowledge benefits all students as they enter the math course sequence.

A transformational change in math placement is possible when ALEKS Placement, Preparation and Learning (PPL) is used alongside multiple measures or as a standalone program to better address the needs of returning students who lack current measures and underserved students with unequal educational opportunities. Nationally, 50% of students who spent at least six hours in the personalized ALEKS PPL learning modules were able to improve at least one placement level higher in a subsequent ALEKS PPL assessment. This is coupled with a 76% average success rate in college-level courses across an analysis of more than 40 two- and four-year institutions. Early evidence of multiple measures implementations has led to increased enrollment in non-STEM pathway courses, such as statistics (Zinshteyn, 2019). ALEKS PPL has been shown to increase math confidence and STEM persistence at a time when the STEM workforce demand has outpaced overall US job growth (Graf, Fry, & Funk, 2018).

A TRANSFORMATIONAL CHANGE IN MATH PLACEMENT IS POSSIBLE WHEN ALEKS PLACEMENT, PREPARATION AND LEARNING (PPL) IS USED ALONGSIDE MULTIPLE MEASURES OR AS A STANDALONE PROGRAM.

Multiple measures may require a large financial commitment from the institution. The SUNY institutions that implemented multiple measures spent $110 per student (or $121,000 per college) in the first year, with a projected ongoing cost of $40 per student (Barnett, et al., 2018). Consideration of the return on such an investment includes not only the number of students placed into college-level courses, but the impact on outcomes across all demographics, inclusion of non-traditional students, differences between math and English placement, and STEM persistence. Qualitative measures include the ability for students to demonstrate productive persistence, the impact granular data can have on curriculum planning, and student perception of the placement process.

A number of states and institutions have found that ALEKS PPL is an effective and affordable solution with as little as a 2.5% increase in retention required to break even on their investment in student success at two-year institutions, which could equate to retaining one student at many four-year institutions. There is a growing body of research showing that, unlike multiple measures or standardized placement tests alone, ALEKS PPL significantly increases student success across all math courses by identifying current math skills. This ensures accurate placement and allows students to improve their placement by repairing prerequisite skills with a personalized learning path. To date, ALEKS PPL is the only math placement program to offer significant supporting third-party and published efficacy research, both at two-year and four-year institutions with varied demographics. Research supports that ALEKS PPL narrows equity gaps by addressing the education debt resulting from differences in prior math opportunities and supports persistence in all pathways, regardless of the student's ethnicity, gender, age, or income.

Evaluating Outcomes of Multiple Measures Placement

Although multiple measures predictive models look more promising when evaluated against traditional standardized assessments, research shows the benefits of ALEKS PPL used alongside multiple measures or as a standalone program can have the most positive outcomes and produce the most tangible benefits when evaluated through the following contexts:

» **Efficacy of studies derived from predictive models versus controlled, randomized research.**

» **Results in math versus English college-level placement and success.**

» **Equity in student success and the impact across all demographics.**

» **Inclusion of returning (non-traditional) students.**

» **STEM Persistence.**

» **Cost versus return on investment.**

Predictive Model Studies

Predictive multiple measure models typically rely on samples of students who were previously placed by standardized placement exams (i.e., Accuplacer or Compass). This produces a narrow lens by which the additional factors are measured and, by design, should lead to a higher validity in the multiple measure predictive models. The following table outlines the predicted improvement in outcomes with multiple measure placement from a widely-cited predictive study conducted from data in an urban community college system (Scott-Clayton, 2012):

**Table 1: Predicted Placement Outcomes in an Urban Community College System**

	Math		English	
	Placement Test Only	Multiple Measures	Placement Test Only	Multiple Measures
Severe Error Rate*	24%	22%	33%	28%
Overplacement	6%	7%	5%	6%
Underplacement	18%	14%	29%	22%
Placed into college-level course	25%	33%	20%	31%
Passed college-level course with a C or better	67%	68%	72%	76%

*The severe error rate is calculated by combining two errors: those who are predicted to get ≥ B in the college-level class but are actually placed in developmental education, and those who are predicted to fail the college-level class but are actually placed directly into that class.

The predictive model for math does produce marginal gains in the number of students placing into a college-level math course, with a 1 percentage point improvement in course success. Nevertheless, even with multiple measures, the majority of students are still not ready for a college-level math course.

When the same predictive model is evaluated for efficacy, controlling for student demographics, the results are not equally effective; this is illustrated in Figure 1 (Scott-Clayton & Stacey, 2015).

Figure 1: Predicted Racial/Ethnicity Composition of Introductory College-Level Courses

By Assessment Methods (Urban Study).
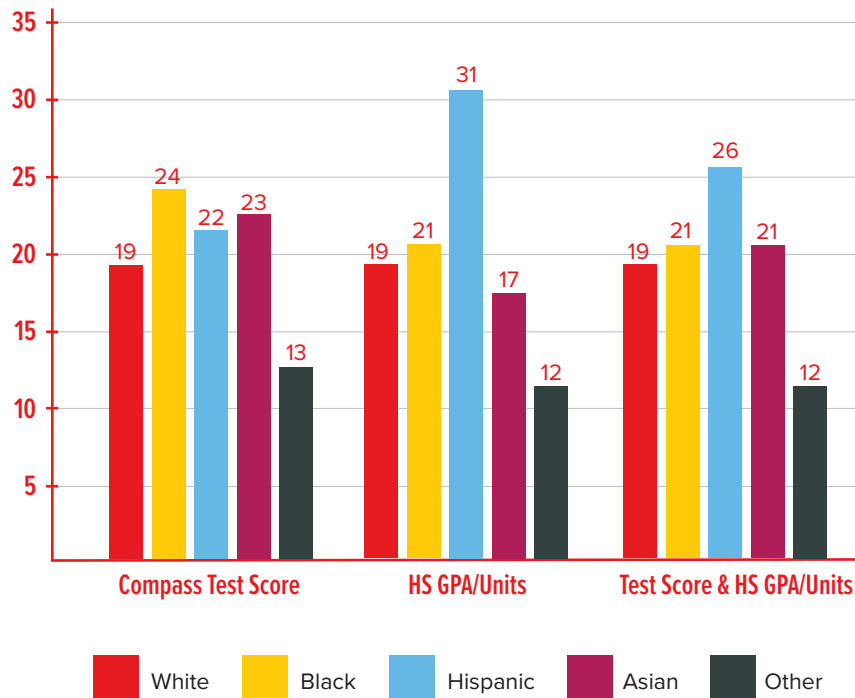
- Fewer Black and Asian students place into college-level math using high school GPA as a factor.
- Hispanic students benefit most from a multiple-measure approach, as they are more likely to place into college-level math under the HS GPA model compared to placement solely by the Compass test.
- There is no change for White students across each treatment group.

Several student groups, including Black, Asian, and Other, benefit more in terms of college-level placement using the Compass test score as the sole measure. The most concerning fact about this point is that ACT discontinued the Compass placement test in 2016 because it proved to be a poor predictor of student outcomes.

Researchers for the California Community Colleges also created a predictive multiple measures model using retrospective data from students with access to high school transcripts and who had already been placed, enrolled, and completed courses in the colleges (ERP, 2018). The predictive model yielded the following placement recommendations and success predictions for students who place directly into transfer-level (i.e., college-level) courses (Rodriguez, Mejia, & Johnson, 2018).

Table 2: California Multiple Measures Assessment Project Success Predictions

Range of HS GPA and Math Course in HS	Course Placed Into Using the MMAP Predictive Model	Predicted Success Rates
GPA >= 3.0	Transfer-level statics/Liberal arts math No additional support required	75%
GPA 2.3 - 2.9	Transfer-level statistics/Liberal arts math Additional support required	50%
GPA < 2.3	Transfer-level statistics/Liberal arts math Additional support strongly required	29%
GPA >= 3.4 or GPA >=2.6 and enrolled in HS Calculus	Transfer-level BSTEM math No additional support required	75%
GPA <= 2.6 and enrolled in HS Calculus	Transfer-level BSTEM math Additional support required	53%
GPA <= 2.6 and no HS Pre-Calculus	Transfer-level BSTEM math Additional support strongly required	28%

A few interesting points to consider:

- While the predictive model suggests increased rates of success for students with higher high school GPAs and advanced math course completion, there is an important distinction between students entering STEM-based majors and those with majors requiring liberal arts math or statistics. For example, low-income students and underrepresented minority students, who make up 60% of the California K-12 student population, often lack access to math support and advanced math courses (Ed Trust-West, 2017). As California colleges phase out remedial math courses, and in the absence of a math skills bridge program, these students now have limited options for pursuing a STEM pathway, as well as a low predicted rate of success (Hensley, Chen, Hong, & Campbell, 2019).

- Forty-two percent of the CA Community College student population is over the age of 25 (California Community Colleges Chancellors Office, 2019). The multiple measures model may not be applicable to this population of students, who might lack access to recent or relevant transcripts or exhibit math knowledge decay.

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Controlled Research and Actual Implementation

A randomized-controlled study of the application of a multiple measure approach for 4,729 students was conducted at five State University of New York institutions. The Fall 2016 results (Barnett, et al., 2018) show marginal gains in college-level placement in math—from 44% to 49%—but the overall actual math course enrollment and completion rate, which went from 14% to 17%, is far below the model's prediction of 68% (shown in Table 1). The results are more profound for English.

Table 3: Actual Outcomes of Multiple Measures Placement at Seven SUNY Community Colleges

	Math		English	
	Placement Test Only	Multiple Measures	Placement Test Only	Multiple Measures
Placed into College Level Course	44%	49%	52%	83%
Enrolled in College Level Course	25%	30%	41%	60%
Passed College Level Course	14%	17%	27%	40%

An innovative large urban community college in California, with minority enrollment of 79%, was one of the first to pioneer a multiple measure placement algorithm, which considered recent high school information and standardized placement test data, as part of the Promise Pathways initiative (Ganga & Mazzariello, 2019). The initial 2012 cohort included 933 students and expanded to approximately 1,500 high school students from the college's feeder school district. The study did not address whether the model was applicable to the 50% of students at the college who were over the age of 22 and might lack recent measures.

The program yielded strong outcomes for English, with assessment into transfer-level (college-level) English increasing from not quite 15% using traditional standardized assessment in the previous cohort to almost 60% when using multiple measures. The number of students successfully completing college-level English increased by almost 30%.

The placement into transfer-level (college-level) math increased from less than 10% to 30%, with 15% (or 156 students) successfully completing their transfer-level math course. Overall success rates dropped to 51%, and **though the study found that all demographics saw gains, the researchers noted there was deeper widening of the achievement gap, with black students' net improvement four times lower than that of white students.**

In 2019, several more colleges from the California Community College System have since implemented multiple measures, yielding strong outcomes in college-level English performance. The October 2019 Public Policy Institute of California report noted that the participating colleges increased the number of students enrolling in a transfer-level math course and most often the course was some form of statistics, a non-STEM pathway. However, the pass rates are lower at all but two of the colleges. (Public Policy Institute of California, What Happens When Colleges Broaden Access to Transfer-Level Courses?, October 2019.)

Efficacy of Common Instruments Used in Multiple Measure Studies

In theory, using more than one measuring instrument should increase the precision of placement. However, such gains may be marginal, and still insufficient if one starts from instruments that are individually poor predictors of success. Based on the review of research, (Bahr, 2016), (Barnett, et al., 2018), (Belfied & Crosta, 2012), (Bracco, et al., 2014), (Federick, et al., 2014), (Scott-Clayton, 2012), we can conclude that there is no universally validated model on how to implement and use multiple measures. Each implementation has its own idiosyncratic rules to combine the measures. There is no expectation or observation of repeatability of a multiple measure implementation from one institution to another.

Key points to consider regarding common tools used as parts of multiple measures include:

Standardized Tests

- **Design of instrument.** Standardized test scores, such as the SAT and ACT, are not recommended for math placement by the Mathematical Association of America (MAA). The MAA states that placement tests seek to measure students' knowledge and skills that are prerequisite for specific entry-level college mathematics courses, while the ACT and SAT measure a broad range of quantitative skills, which is often too general to distinguish between readiness for entry-level mathematics courses (The Mathematical Association of America, 2010).

- **Time lapse.** SAT and ACT scores are typically taken well in advance of enrollment at a post-secondary institution, and may not relate to a student's current mathematical ability. This time lapse could result in potentially under- or over-placing students, depending on their continued mathematical coursework (or lack thereof) (Reddy & Harper, 2011), (Reddy & Harper, 2013).

- **Equity.** The College Board's 2016 Total Group Profile Report reveals the equity gap in average SAT Math scores by Ethnicity and Household Income. (CollegeBoard, College-Bound Senior Report, 2016).

Table 4: SAT Mean Math Score by Ethnicity for 2016 College-Bound Seniors

Test-Takers Who Self-Describe As:	Avg. SAT Math Score
Black or African American	425
Native Hawaiian or Pacific Islander	438
Hispanic, Latino, or Latin American	453
American Indian or Alaska Native	471
No Response	501
Two or More Races, non-Hispanic	505
Other	519
White	533
Asian or Asian American	602

Table 5: SAT Mean Math Score by Family Income for 2016 College-Bound Seniors

Test-Takers Who Self-Describe As Having a Family Income of:	Avg. SAT Math Score
Less than $20,000	453
About $20,000 to $40,000	477
About $40,001 to $60,000	495
About $60,001 to $80,000	509
About $80,001 to $100,000	527
About $100,001 to $140,000	539
About $140,001 to $200,000	553
More than $200,000	586
No Response	501

Note: The Brookings Institution states that the race gaps on the 2016 ACT are comparable to those observed for the SAT (Reeves & Halikia, 2017).

High School GPA and Transcripts

There are some practical concerns about using high school transcripts for making placement decisions. Some students may not have transcripts, or they may have incomplete transcripts. Others may have completed high school many years ago, such that their high school performance is not an accurate representation of their present-day knowledge. Furthermore, evaluating transcripts may slow down the placement process (Belfied & Crosta, 2012).

Researchers have also questioned the reliability of high school grade point average because it does not account for comparability across schools, which can differ in course rigor and grading standards, availability of highly qualified teachers, and economic inequities, among other characteristics (Camara & Michaelides, 2005) (Sackett, Borneman, & Connelly, 2008).

Regardless of the last math class taken and GPA, many colleges find students are not ready for college level math courses. This assertion is supported by the ACT organization, which reported that college math readiness is at a 14-year low, with only 40% of those completing the ACT in 2018 demonstrating they could succeed in a first-year college algebra class (ACT, 2018). The NCES found that high school math scores have remained flat for the past 40 years, with 59% of students presenting as unready for college math (National Center for Education Statistics, 2013). Colleges and universities must identify and bridge the gaps to ensure college success and readiness for today's workforce demands, while avoiding enrollment into developmental math courses.

Standardized Commercial Placement Tests

College Board's Accuplacer Exams and ACT's Compass (now discontinued) have historically been the mostly widely used placement mechanisms and are implemented as "one-shot-deal," high-stakes multiple-choice tests. In recent years, their efficacy has come into question and fueled the multiple measures movement.

- ACT announced in 2015 that they were phasing out the Compass test for reasons including the "doubt about the test's predictive value" and its placement of high proportions of students in developmental courses, further stating that many adult students who place into remedial courses with Compass might be able to thrive in college-level courses after taking a brief refresher on academic material that they haven't seen for a while (Fain, 2015).

- The College Board states that the best practice for placing students into college-level courses is with the use of multiple factors along with Accuplacer test scores (The College Board, 2019).

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Brianna Swain's college aspirations were sparked by her connection with TRIO, a program funded by the Department of Education which supports underserved schools. Brianna's successful college journey began with ALEKS PPL. Knowing her ACT score did not place her into credit-level math, Brianna took the ALEKS PPL placement assessment. She placed into Intermediate Algebra, but was able to refresh missing math skills in her personalized Prep and Learning module, allowing her to place into co-requisite College Algebra. Brianna is now a graduate of Columbus State Community College and a math major at Ohio State University.

Comparing Outcomes to ALEKS PPL

What is ALEKS?

"ALEKS," an acronym for Assessment and Learning in Knowledge Spaces, is a web-based, adaptive, artificially intelligent education program. ALEKS is the practical realization of Knowledge Space Theory, which is the result of ground-breaking research in mathematical cognitive science initiated by Professor Jean-Claude Falmagne at New York University (NYU) and the University of California, Irvine (UCI) and Professor Jean-Paul Doignon at the University of Brussels. The core mathematical theory was created with the financial support of several National Science Foundation (NSF) grants to Falmagne at NYU and UCI. Since 1999, ALEKS products have been used by millions of students in math, science, and business courses. ALEKS Placement, Preparation and Learning ("ALEKS PPL") is a comprehensive approach to accurately assessing and preparing students for success in college-level math.

In contrast to standardized tests, which typically result in numerical measures of achievement or "aptitude," an ALEKS assessment results in (i) the precise and comprehensive delineation of an individual's competence in a subject in the form of his or her knowledge state describing all the types of problems

mastered by that individual, and (ii) a comprehensive list of the topics the individual is ready to learn (referred to in Knowledge Space Theory as the outer fringe of that individual's knowledge state). The ALEKS placement assessment delineates, by efficient, open-response adaptive questioning, the knowledge state of the student; i.e., exactly which topics the student has mastered and which topics the student has not mastered.

The combination of assessment and learning offered by ALEKS greatly enhances the student's likelihood of success in his or her first college math course because it allows the student to "clear the cobwebs" from math knowledge previously gained. Equally important to students and institutions is the information ALEKS PPL provides on the initial level of preparedness of each student and the potential for students to overcome gaps in knowledge to meet the requirements for a higher-level course than the initial assessment results would indicate.

The following outlines the impact of ALEKS PPL across key areas: Efficacy, Equity, Inclusion, STEM Persistence, and Return on Investment (Cost).

Efficacy of ALEKS PPL

A student may be short of readiness for a course, but this does not necessarily mean that placement into the prerequisite course is warranted. The learning modules in ALEKS PPL can bridge the specific issues in a much shorter time span and a more cost-effective manner:

- In reviewing data of more than 430,000 students who used ALEKS PPL from Oct. 2016 to Feb. 2017, 50% of students who spent at least six hours in the personalized ALEKS PPL learning modules were able to improve at least one placement level higher in a subsequent ALEKS PPL assessment.

- Nationally, 40% of students who placed initially in developmental mathematics courses were able to improve their placement result in a subsequent placement assessment, qualifying them for placement into many of the math pathway or corequisite courses offered nationally.

- Moreover, 27% of those who initially placed in developmental mathematics courses were able to improve their placement into College Algebra level courses or above after another placement assessment attempt in ALEKS PPL.

In an analysis of more than 89,000 students across more than 40 two- and four-year institutions, ALEKS PPL proves to be a strong predictor of course success:

- **64% average student success rate** (grade of C or better) in developmental math courses.

- **76% average student success rate** (grade of C or better) in college-level math courses and higher.

As noted in the national data above, the number of students qualifying for and succeeding in college-level courses under ALEKS PPL is significantly higher than what was achieved with the previous placement process, ACT's Compass. Institutions across the country have increased student success with ALEKS PPL, including William Rainey Harper College in Illinois, where ALEKS PPL is used for math placement in combination with other measures.

William Rainey Harper College partnered with **Vanderbilt University** to conduct a controlled-randomized study comparing ALEKS PPL to ACT Compass. They found that ALEKS PPL students were:

- 7–9% more likely to place in a college-level math course compared to the control group, which used Compass.

- 19% more likely to receive a "C" or better in their college-level course.

- 22.5% more likely to stay enrolled at Harper College for a second semester.

- More likely to improve course placement; 82% of students who reassessed with ALEKS PPL improved, compared with 36% for students using Compass.

Equity

The use of the last completed high school math class for placement decisions penalizes many underrepresented minority and low-income students. Research indicates that these students lack access to the same math support resources to succeed in their core curriculum, and are unable to enroll (due to availability and/or eligibility) in advanced math courses at the same rate as certain peer groups. The US Department of Education's Office of Civil Rights found that Latino and African-American students were less likely to pass Algebra 1 and, when compared with their White and Asian peers, they were also less likely to attend high schools that offered advanced math classes (US Department of Education Office for Civil Rights, 2018). When evaluating 12th grade math achievement levels, NCES reported that 63% of Black students and 51% of Hispanic students were classified as "below basic," and only 3% and 4%, respectively, were "at or above proficient" (Braswell, et al., 2001). For these reasons, colleges have found that the ability to review and reassess is critical for underrepresented minority and low-income students, so they are not penalized for educational inequities, but rather given an opportunity to improve skills and demonstrate persistence. Implementations of ALEKS PPL and ALEKS Course Products in the classroom have shown to have a positive impact on bridging equity gaps.

- Prior to their course redesign in 2012, **Columbus State Community College's** developmental math pass rates were close to 50%. After redesigning into a lab-based model and implementing ALEKS PPL and ALEKS Course products:

  - By 2018, 68% of students were successful in their redesigned developmental course.

  - Retention rates in developmental math grew from 49% to 65%.

  - Performance across demographic groups improved, notably African-Americans who had a seven percentage point increase

  - Since the implementation of an ALEKS PPL boot camp in the first week of their developmental courses, about 30% of students have been able to move up at least one placement level.

- At **Arizona State University** ALEKS is used for placement and in the College Algebra Course. Under-represented minorities in College Algebra have shown a 20 percentage point gain in success rates, as have first-generation college students.

- Research at the **University of Memphis** regarding racial disparities in undergraduate statistics courses found that the traditional one-letter-grade race-gap between White and Black students in this course was eliminated when ALEKS was used (Hu, Luellen, Okwumabua, Xu, & Mo, 2019).

- The **University of California, Santa Cruz**, is a Hispanic-Serving Institution with a highly diverse student population, including 37% first generation college students, 37% Pell Grant–eligible, and 32% underrepresented minority students. Despite differences in prior educational experiences and opportunities, by providing each student the ability to review and reassess, use of ALEKS PPL has resulted in a narrowing of equity gaps. Those who review and reassess in ALEKS PPL improve their placement, with six out of seven students who initially placed into College Algebra improving placement. Regardless of the students' backgrounds, those who review, reassess, and advance placement were found to be as likely to pass and earn a B or better as a student who placed initially in the class. Furthermore, grades in subsequent classes were comparable for both groups (Lewis, 2019).

- The **City College of San Francisco**, a Hispanic-Serving Institution, created a summer math skills program using ALEKS PPL and found that:

    - 70% improved course placement.

    - Summer Bridge students had a 15% increase in course success and a 10% increase in retention.

    - Participating Latinx students beat the average course success rate for all incoming students, with a 12% higher course success rate in math than their Latinx peers who did not participate.

- The **University of Nevada Las Vegas**, a Title III & Title V Minority-Serving Institution (MSI), created a Math Bridge program to improve math skills and placement. The research found that 70% of their students placed into college-level courses after working in ALEKS PPL, saving the students time and money, as well as expediting their path to graduation (Appleton, 2019).

Inclusion

Returning students over the age of 25, who represent 44% of the public community college population, may have been out of high school too long for multiple measures alone to be an accurate predictor of course success (Ma, Baum, Pender, & Libassi, 2018). Multiple measures considers the last math class completed, but many returning students have lost that prerequisite knowledge. Even recent high school graduates lose 25-30% of their previous year's education over just the short summer break, with Black and Latinx students showing greater loss compared with White students (Quinn & Polikoff, 2017). Therefore, even if the student has previously completed a prerequisite high school course, there is no assurance the student has mastered or retained the necessary math topics to be successful in the next course.

Corequisite courses help bridge conceptual gaps and ALEKS can help form that support class curriculum. For students with vast and varied knowledge gaps, ALEKS PPL provides a personalized learning path to repair skills and confidence in advance of a formal math course. This review might be over several hours or in a skills bridge program, which have become increasingly common, such as Utah Valley University's MATH 100R course.

The State of Utah has a high number of young people (aged 18-21) who leave for two years of religious service and need to re-establish their placement in math courses upon return. These students were routinely placed into low-level developmental math courses by Accuplacer and required to complete multiple math courses before enrolling in a college-level math course. At Utah Valley University, an open-enrollment institution, 70% of incoming students were deemed not ready for college-level math based on Accuplacer results. The key component of UVU's implementation of ALEKS PPL is the creation of a 1.0 credit hour course called MATH 100R and Math Leap, which is a guided placement preparation course taught by full-time math faculty. Advisors recommend students take MATH 100R during their first semester instead of attempting to take a regular math course, with the goal of saving students time and money. Under this model, UVU has experienced 50% lower developmental math enrollments, saving students approximately one million dollars in tuition within the first two years of implementation. This was calculated by multiplying the number of courses skipped by students with ALEKS PPL versus the tuition the students would have paid had they enrolled in those courses.

STEM Persistence

The multiple measures approach of including metrics such as high school GPA, last completed high school math class, and standardized test scores could further impact the STEM disparity in an institution's recruiting and retaining underrepresented minority and low-income students. As seen in the California research, given the low-predicted rates of success when students have not previously completed precalculus in high school, low-income and underrepresented minority students see fewer viable paths to a STEM career. However, STEM persistence is critical at a time when our country needs STEM majors most and job opportunities in STEM are the most available. The Pew Research Center reports that "employment in science, technology, engineering and math (STEM) occupations has grown 79% since 1990, from 9.7 million to 17.3 million, outpacing overall US job growth," with STEM majors earning 26% more than their non-STEM peers (Graf, Fry, & Funk, 2018). However, companies have found a shortage of qualified applicants, and that even non-STEM careers require STEM skills. ALEKS PPL allows all students the opportunity to review and reassess, so they may reach course goals and keep in-demand and lucrative career paths open.

Given the realities of today's workforce, the math placement and competency discussion shines a light on an educational inequality which may perpetuate and exacerbate the economic disparities among underrepresented minority and low-income students who currently lack access to the same K-12 math opportunities as their peers. It is not surprising that underrepresented minorities, who make up 30% of the US population, only represent 12.5% of STEM majors (National Action Council for Minorities in Engineering, 2019). Without a proper math foundation, pursuing a STEM path is unlikely. ALEKS PPL provides an opportunity to refresh necessary prerequisite skills and restore math confidence, allowing for all paths to remain viable.

- **Iowa Central Community College** saw a 21% increase in STEM course enrollment under the implementation of ALEKS PPL.

- **University of California, Santa Cruz** (UCSC) has a diverse student population with significant numbers of first generation, Pell Grant–eligible, and underrepresented minority students. Roughly half of UCSC's undergraduates major in STEM disciplines (Lewis, 2019). UCSC found that since ALEKS PPL was implemented, more students are placing in advanced classes without endangering their academic success. For example, in year one of their ALEKS PPL implementation, the yearly enrollment in MATH 2 (College Algebra for Calculus) dropped by half, from more than 800 to fewer than 400, and yet pass rates in all the relevant math courses remained roughly the same. Students who used ALEKS PPL to "work their way up" into MATH 3 (Pre-Calculus), MATH 11A/11B (Calculus with Applications), or MATH 19A/19B (Calculus for Science, Engineering and Mathematics) did as well as those who placed into the same courses from the start, once other factors known to affect performance were taken into account. They had comparable grades and pass rates, and perhaps most importantly, comparable grades in the next math course they took (University of California Santa Cruz, 2017).

"TO ADDRESS THE KEY INEQUITY IN STEM FIELDS, WE HAVE IMPLEMENTED AT LINCOLN UNIVERSITY THE USE OF ALEKS PPL & ALEKS COURSE-INSTRUCTION, AN INNOVATIVE AND ADAPTIVE LEARNING TOOL, ALONG WITH A NEW PEDAGOGICAL APPROACH TO OUR MATH LABS FOCUSING ON PROBLEM-SOLVING AND CRITICAL THINKING SKILLS. THESE INNOVATIVE INTERVENTIONS HAVE GENERATED MEASURABLE IMPROVEMENTS IN STUDENT SUCCESS IN GATEKEEPER MATHEMATICS COURSES."

— Claude Tameze, Ph.D., Chairman & Associate Professor, Director of Mathematics Learning Center, Department of Mathematical Sciences, Lincoln University, Pennsylvania
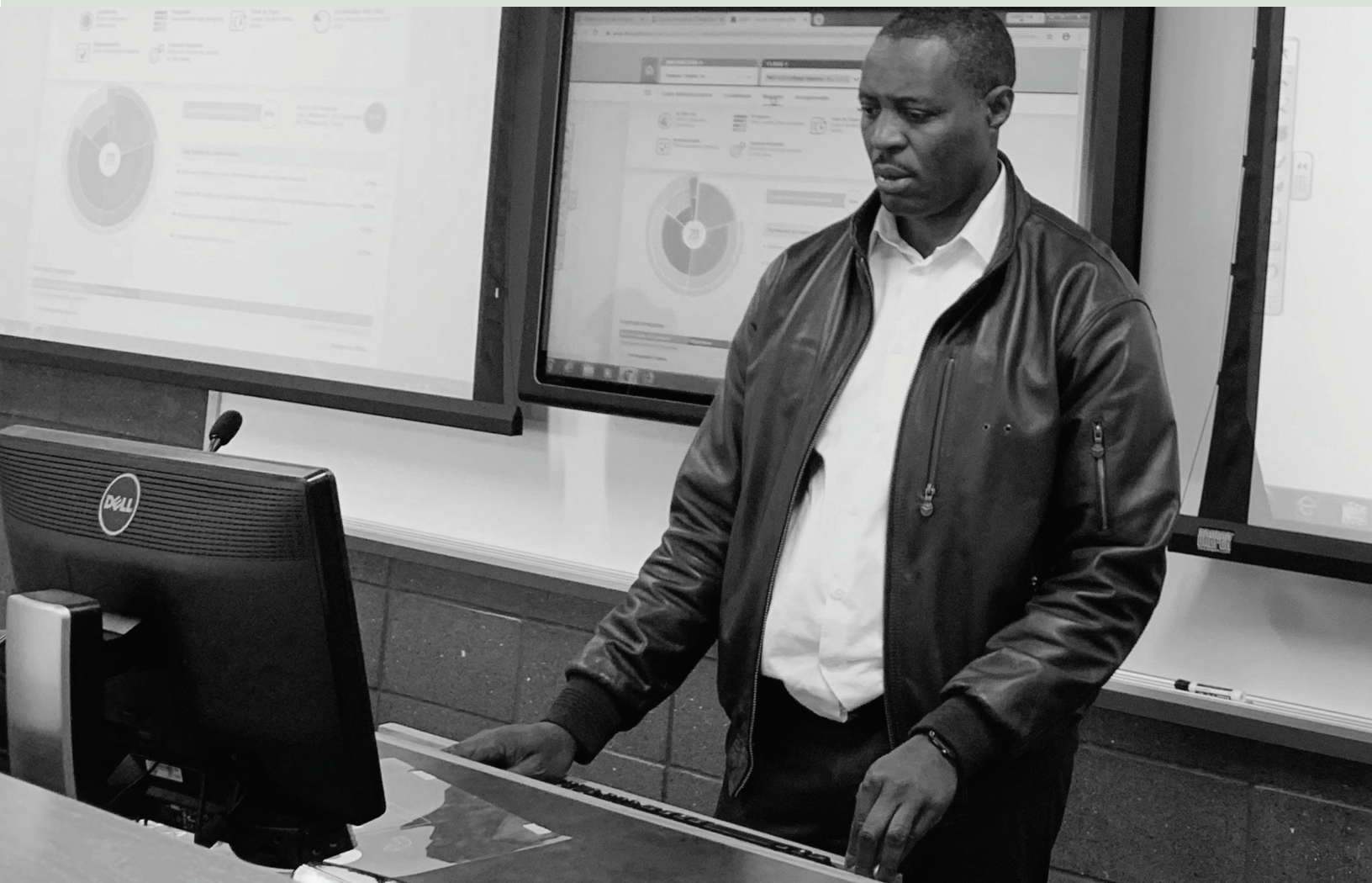
Return on Investment

The implications of poor placement can have far-reaching negative effects for both students and institutions, while the impact of a comprehensive math placement program, supporting all demographics, can provide a significant and measurable return on investment in student success.

Placement into the appropriate math course (and pathway) has been shown to be the first step to a successful college career. Research shows that success in a student's first math course is the best predictor of the student attaining a degree (Harrington, Lloyd, Smolinski, Shahin, & M., 2016), (Parker, 2005). Furthermore, retaining students at an institution directly impacts the institution financially in terms of tuition, fees, and state funding, as well as the investment (time, resources, and money) required to recruit and admit more students to mitigate attrition.

Students who are successful in their first math course:
- Are more likely to enroll in higher-level math courses.
- Experience a greater range of career options.
- Save on tuition by lowering the cost of re-instruction.
- Save on course materials and fees.
- Save six or more months of class time.

Institutions using ALEKS PPL report:
- Improved course success rates.
- Increased STEM enrollments.
- Better knowledge of what courses students need.
- Accurate hiring of faculty and classroom scheduling.
- Maximizing student turnout and class participation.
- Increased retention of students at the institution.
- Increased state funding due to higher graduation rates.
- Lower advising costs.

Evaluating the year-one cost and success rates of the SUNY Multiple Measure Study and ALEKS PPL national data supports that ALEKS PPL can help institutions considering or using multiple measure approaches improve their overall return on investment. While the analysis compares year-one expenditure and resulting course success rates, there are many non-quantifiable benefits to ALEKS PPL. These include data and analytics on student mastery of math concepts for curriculum planning across the math and STEM sequence, as well as an opportunity for students to demonstrate productive persistence in the Prep and Learning Module.

The SUNY institutions that implemented multiple measures spent $110 per student (or $121,000 per college) in the first year, with a projected ongoing cost of $40 per student (Barnett, et al., 2018). A typical spend of $25,000 on ALEKS PPL in year one results in a 76% college-level math success rate across two- and four-year institutions.

Figure 2: Initial (Year 1) Investment in the SUNY Multiple Measure Model and ALEKS PPL Models based on 1,000 Students.

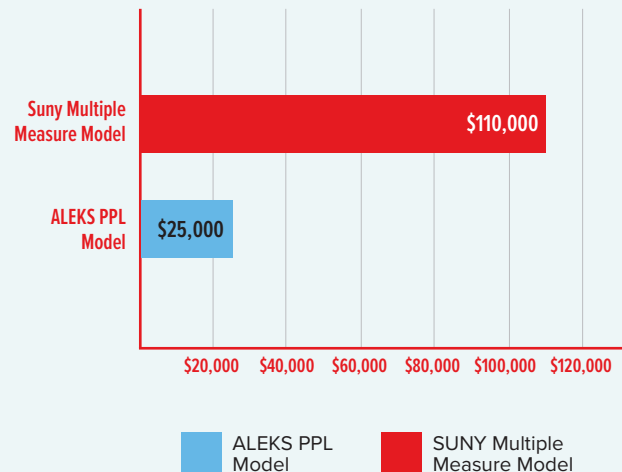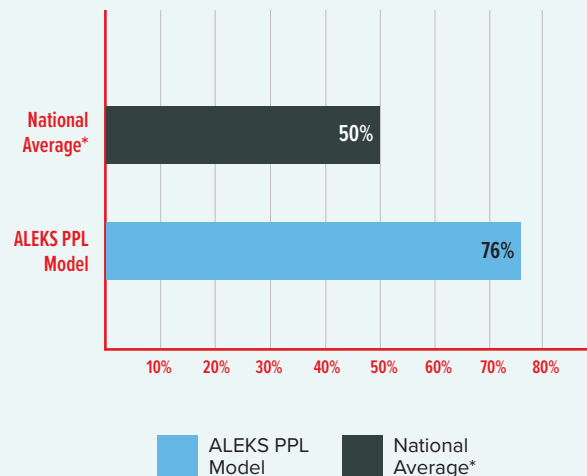Year 1 Investment in Placement Model
(Per 1,000 Students)

Figure 3: Success Rates in College-Level Math: National Average and ALEKS PPL Model.

Resulting Success in College-Level Math

*Based on data from A Common Vision for Undergraduate Mathematical Sciences Programs in 2025 (Saxe & Braddy, 2015).

Conclusion

ALEKS PPL, whether used alongside multiple measures or as a standalone program, can significantly increase student success and promote educational equity. ALEKS PPL uniquely addresses the education debt resulting from differences in prior math opportunities and supports persistence in all pathways, regardless of the student's ethnicity, gender, age, or income. ALEKS PPL can help institutions better serve the needs of returning students who lack current measures, underserved students with unequal educational opportunities, and students who desire a STEM pathway.

ALEKS PPL significantly increases student success across all math courses by identifying current math skills. This ensures accurate placement, and allows students to improve their placement by repairing prerequisite skills with a personalized learning path. The data generated by ALEKS PPL can be used by institutions to inform curriculum design and topics emphasized in the classroom (e.g., corequisite support courses). ALEKS PPL can be used in brief bridge programs, acting as another form of a college-level support course by refreshing the needed prerequisite skills without requiring students to complete several semesters of developmental math. With ALEKS PPL, students and institutions can make data-driven decisions about curriculum, course enrollments, and pathways.

WITH ALEKS PPL, STUDENTS AND INSTITUTIONS CAN MAKE DATA-DRIVEN DECISIONS ABOUT CURRICULUM, COURSE ENROLLMENTS, AND PATHWAYS.

The many innovations and policy changes in math redesign are commendable and inspiring as each institution seeks the best way to increase student success, retention, and graduation rates, particularly among the most vulnerable: underrepresented minority, low-income, returning, and first-generation students. A deeper evaluation of the multiple measures placement outcomes reveals the benefits of pairing multiple measures with a nontraditional, evidence-based math placement program, which produces significantly higher course pass and retention rates for all students at lower costs.

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