PROCTORED VERSUS UNPROCTORED MATH PLACEMENT TESTS: DOES IT MATTER?

A Dissertation
Submitted to
the Temple University Graduate Board

In Partial Fulfillment
of the Requirements for the Degree
DOCTOR OF EDUCATION

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Diploma Date December 2022

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ABSTRACT

Many institutions use placement tests as a method to assess students' readiness for college-level coursework. With the increased use of technology in testing, many institutions have transitioned placement test administration to an online format in an unproctored setting. While unproctored placement tests may provide financial and logistical benefits for institutions and students, it is important to examine if there are differences in academic outcomes when tests are administered in this format. Guided by the literature on test administration modality (i.e., proctored versus unproctored examinations), I examined if there are differences in math course performance and college student enrollment persistence between students who completed a proctored or unproctored math placement test. To investigate these important educational outcomes, I analyzed data collected as part of a 2018 randomized control trial conducted at a large, urban public institution in the Mid-Atlantic region of the United States in which incoming, first-year students were randomly assigned to a proctored or unproctored group to complete a math placement assessment. The current study affirmed findings from a pilot study, which suggests that students tend to place approximately one course level lower when placed using a proctored math placement test compared to an unproctored placement test and that students tend to have higher final grades in their initial math course when placed by a proctored math placement test.

The current study analyzed final grades in the second math course taken between proctored and unproctored groups as well as student persistence. Analyzing mean course grades, I found that differences in grades between students who take a proctored and unproctored math placement test continue in some cases into the second math course. The percentage of F's and withdrawals for initial and second math course final grades between students who take a proctored and unproctored math placement assessment also show differences between groups. Applying hierarchical linear regression, suggests that test administration modality does not account for a significant amount of

variance in course grades. When controlling for demographic characteristics and academic factors, performance from the initial course taken, was found to be the most significant factor of grades in second math course taken.

Results from the current study suggests that test administration modality during math placement tests while not a statistically significant variable in academic performance in second math course taken, may still be helpful as it is a statistically significant variable in academic performance in the first math course taken. Since initial math course grades were statistically significant in explaining the difference in grades between groups, institutions should consider using proctoring during math placement tests as a practice.

Further research should be conducted, however, to understand how test administration modality during placement tests affects students in different programs, including programs that do not require courses along the institution's math course sequence. Additionally, further research on types of proctoring would provide a more comprehensive understanding of the proctoring options available to institutions and whether they result in the same outcomes for students.

Keywords: Placement Testing, Proctoring, Student Success, Regression Analysis

DEDICATION

This dissertation is dedicated to my parents whose support and encouragement of my education has always been unwavering. It is dedicated to my children, Emily and Violet, who teach me every day and never stop asking why.

I hope that through my work and actions that I may support, encourage and teach others and never stop asking why.

ACKNOWLEDGMENTS

It is with sincere humility that I recognize that this dissertation would not have been possible without the tremendous support and guidance from others. I would especially like to thank my chair, Dr. Joseph DuCette, and committee members, Dr. Tim Fukawa-Connelly, Dr. Joseph Paris, and Dr. Ben Torsney. To Dr. DuCette, your dedication and commitment to your students, including myself, is unprecedented. Your direction and mentorship was greatly appreciated throughout the process. To my other committee members, thank you for challenging me with new ideas. Your enthusiasm and feedback along this journey were invaluable.

I am also extremely grateful for my colleagues. They have provided both support and mentorship. I consider myself fortunate to have a career in a profession where education is highly regarded.

Finally, I want to thank my family. My parents have always supported my education and ensured that I had every opportunity to pursue my goals. I fully recognize that their values of determination and belief in education are what led me here, today. My husband has provided much support for our family and exhibited patience so that I could complete this journey. Lastly, my children who do not fully understand what I accomplished and the work it took, but who have given me the motivation needed to keep going. I hope to be an example of what they can accomplish and to support them to ensure that they have every opportunity to pursue their goals.

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CHAPTER 1

INTRODUCTION

Students enter college with a wide range of backgrounds, experiences, and academic proficiencies. At many institutions, courses in certain subjects, such as math and English, are taken in a particular sequence. Incoming students register for a particular course within the sequence that is most aligned with their proficiency in the subject matter as determined by placement test results. Course sequences are designed with the intent that students can gain sufficient skills in a subject before proceeding to take more advanced courses.

Institutions determine what should be an appropriate course placement for their students. To assess students' academic proficiencies and to place them into the course level deemed appropriate for the student by the institution, including developmental courses, institutions establish and apply course placement policies using student data and/or placement test results (Abraham, 1992; Barnett & Reddy, 2017; Fields & Parsad, 2012; Frisbie, 1982). Institutions that opt to administer placement tests to make decisions about course placement for incoming students administer them prior to course registration.

Placement tests vary widely by type of assessment tool used and whether the score results in a recommended or required course for students to complete. In addition, placement tests vary widely by modality (Abraham, 1992; Hample, 2018[1]; Hughes &

[1] This citation references unpublished raw data on longitudinal trends in placement testing. Data show that placement tests vary in terms of test policies, what test is used, whether the test is administered online, if the test is proctored, etc.

Scott-Clayton, 2011). Placement tests vary in the ways they are administered (Hample, 2018). For example, institutions may choose to administer placement tests in-person on a campus, in a testing facility, or remotely at a location of the student's choice. They may also choose to administer placement tests electronically (computer-based) or in a paper-and-pencil format. Placement tests may also vary in test administration modality, including in a proctored or unproctored setting.

The transition to electronic and remotely administered tests is relatively new to testing. Historically, tests were administered in-person via paper-and-pencil until the 1980s when computer-based tests began to be used more widely (Foster, 2013). As students became more familiar with technology-based testing and technology became more accessible, educational assessments have moved towards computer-based test formats (*Standards for Educational and Psychological Testing*, 2014). Institutions increasingly use technology to administer tests with the goal of leveraging the benefits of technology-based testing such as a perceived streamlining of the testing process for both students and institutions. In some situations, the transition to technology-based testing emerged because of factors beyond the testing program's control. For example, because of the COVID-19 pandemic, many institutions had to consider different ways to assess students due to stay-at-home and social distancing orders (Bickerstaff et al., 2021; Redden, 2021). As institutions transition to online placement testing, many have also made the decision to administer tests in an unproctored setting (Hample, 2018; Redden, 2021). According to the *Standards for Educational and Psychological Testing* (2014), professionals have the responsibility to determine whether proctoring is necessary for

their assessments by considering what the test measures, how the test will be used, and the use of proctoring in assisting test takers through the assessment. Amid the COVID-19 pandemic, some institutions likely made the decision to administer unproctored placement tests due to logistical factors, such as public health concerns and financial constraints (Bickerstaff et al., 2021).

Placement test administration through in-person, proctored assessments may pose specific challenges to institutions. For institutions that admit students who reside a substantial distance from campus, such as international students, in-person placement testing can pose logistical and financial challenges. These challenges have become even more difficult during the COVID-19 pandemic (Redden, 2021). Moreover, institutions must accompany the students when they arrive on campus to complete testing, which requires institutions to have a testing operation that can perform the activities at a scale that at least meets the size of the incoming student class.

For in-person and remote proctoring formats, there is a cost to the institution for test administration. These costs may include paying for staffing, facilities, or proctoring vendor services. Rodriguez et al. (2015) investigated the costs of placement testing, citing more than $100,000 in annual expenses incurred by the institutions included in their study. Their findings suggest that placement testing is costly to institutions in terms of labor, and to students who incur costs associated with travel to a testing site or preparing for a test. Institutional costs alone are mostly attributed to the labor required to administer tests, accounting for approximately 75 percent of the costs (Rodriguez et al., 2015). By using an unproctored modality, the institution could save 75 percent of their test

administration costs annually (i.e., over $75,000 annually). Bickerstaff et al. (2021) also suggest that the COVID-19 pandemic impacted the institutional costs of test administration. For institutions that decided to continue assessing students using proctored placement tests, additional resources were required to either pay for a remote proctoring service or proctor assessments remotely with current test administration staff. Institutions have increasingly implemented unproctored placement tests to ease the logistical burden and lower costs.

Despite the apparent benefits, administering online unproctored placement tests has reliability and validity concerns (*Standards for Educational and Psychological Testing*, 2014). Unproctored tests are not administered by a proctor who is responsible for ensuring that the test is administered in a standardized way, potentially allowing test takers to gain an unfair advantage. When a test is administered without a proctor, it is difficult to ensure that testing protocols and specifications are followed such as prohibiting the use of resources such as calculators, computer software and applications, cell phones, dictionaries, and other individuals as indicated by test specifications (Foster, 2013; *Standards for Educational and Psychological Testing*, 2014).

It is critical for institutions and students that the test is administered in a way that produces the most reliable and valid results. The reliability and validity of placement tests are critical to institutions that use the placement test results to place students into courses as deemed appropriate by the institution. If the test is not reliable and valid, the institution is unable to use the information from the test to determine course placement. The use of unreliable and invalid data may lead to an inaccurate prediction of students' course

placements, or the misalignment between the course placement and a student's academic readiness. Inaccurate prediction of students' course placement or misplacement can negatively impact students, such as by decreasing retention or increasing stop-outs for student placed into unnecessary remedial coursework (Burdman, 2012). Presumably, misplacement also impacts students through poor course performance, delayed degree completion, and increased tuition costs as a result of additional courses taken. If students are placed above or below courses that they are academically prepared to take, they could face these issues. Ultimately for institutions that use tests to evaluate students' academic proficiency for course placement, placement tests are only helpful if they result in a reasonable method to determine academic readiness in courses.

Statement of the Problem

The purpose of placement tests is to predict the course level at which incoming undergraduate students are most likely to succeed. The importance of valid and reliable course placements is highly relevant for entry level math courses that build on each other in a sequential order (e.g., pre-calculus is a prerequisite for calculus, college algebra is a prerequisite for pre-calculus, etc.). Course placement that results in an inaccurate prediction of course placement can be detrimental to students and the institution. As institutions change test administration protocol, it is important that they consider the potential costs of an inaccurate prediction and whether changes in protocol can impact the validity and reliability of placement tests.

Institutions strive to retain students who enroll as part of their enrollment goals (Hossler & Bontrager, 2015). Misplacement can make achieving institutional strategic

enrollment goals challenging. For example, Tinto (1975) suggests that grade performance is part of the academic system that, along with other factors, predict whether a student persists. Since course placement correlates with grade performance, placement processes are a mechanism by which institutions can support student persistence. Institutions lose potential tuition revenue when student persistence declines. Over-placing students into developmental courses may result in less students completing a particular course sequence (Burdman, 2012). Misplacing students into developmental education results in increased costs to provide courses and academic support to these students (Rodriguez et al., 2014; Rodriguez et al., 2015). There are broader financial implications for other outcomes such as graduation and dropout rates (Bettinger & Long 2009; Boatman & Long, 2018). Poor graduation and persistence rates may affect an institution's reputation among prospective students, alumni, employers, ranking agencies, accreditors, policymakers, and other postsecondary educational stakeholders.

Since course placements are factors in attaining strategic enrollment goals, it is important for institutions to ensure that their placement process is as accurate as possible. For institutions that choose to use a placement test to determine student course placement, changes in test administration modality need to be evaluated to understand if there are differences in course placements and students' academic success so decisions can be made that either increase or at minimum do not reduce test reliability and validity.

Purpose and Significance of the Study

The purpose of this research was to examine if there are differences in math course performance and college student enrollment persistence between students who

complete a proctored or unproctored math placement test. In 2018, Martin et al. (2019) conducted a pilot study in which students took a placement test either in a proctored or unproctored setting (Martin et al., 2019). Findings from the pilot study suggest that students who were assigned to the unproctored test administration placed into higher math courses and obtained significantly lower grades as compared to students who took the placement test in a proctored modality. In addition, students in the unproctored condition obtained more F's and withdrawals in their first semester math course than students who were assigned to the proctored placement test administration.

Findings of the pilot study guided the design of my study. In my study, the 2018 pilot study student cohort and a panel of data from 2018-2021 were used to analyze if there is a difference in performance on the second math course taken. In addition, student persistence between students who were proctored and unproctored during math placement tests was analyzed. My study was designed to allow conclusions to be drawn about whether there are statistically significant differences in educational outcomes for students as a result of proctored placement tests. If differences are found, this would be one source of data to either support or refute the use of proctored math placement tests in the setting in which this study was conducted. Understanding the differences of proctored placement tests can be used by institutions to make informed decisions about placement testing policy and whether the use of proctoring outweighs the financial and logistical benefits of unproctored tests.

The null hypothesis is that there is no difference in second math course performance or persistence between students who take a math placement test in an

unproctored or proctored setting. However, prior studies on classroom exams suggest that proctoring does lead to differences in student academic performance with students performing lower on proctored assessments than unproctored (Alessio et al., 2017; Daffin & Jones, 2018; Goedl & Malla, 2020; Prince et al., 2009). In addition, findings of the aforementioned pilot study suggest that, on average, the results of proctored math placement tests place students one course level lower (less advanced) than the results of unproctored tests. The pilot study also found that students in the proctored test administration group obtained significantly higher grades in the initial math course taken during the student's first semester (Martin et al., 2019). Given these findings, it is reasonable to hypothesize that success in the initial math course will lead to further success in subsequent math courses. It is also reasonable to hypothesize that this continuing level of successful course performance would have an impact on a student's decision to persist at the institution in which they were enrolled.

While it is reasonable to believe that success in the initial math course will lead to further success in subsequent math courses and persistence, it is also recognized that many complex interactions exist. Among others, students are enrolled in a wide array of degree programs with varying math requirements. Students' initial math course varies based upon their placement assessment results, and their pathway through college and their math course requirements are not all the same. In addition, the initial and subsequent math courses are taught by different instructors and factors such as student motivation add more complexity to understanding if there are differences in students' academic success between proctored and unproctored groups. An ideal study to test the effect of

proctoring would be to randomly assign students into a proctored or unproctored assessment group in which they are all required to test, and students would enroll and complete the math course they are placed into with the same instructor and instructional modality followed by the same second level math course with the same instructor and instructional modality in the next semester. Such a study could lead to inferences about whether proctoring has a significant effect if there were differences in math course performance between the two groups. However, the study described is not possible at the study site, nor, in general, in most institutions of higher education. My study instead used data from students randomly assigned to proctored and unproctored assessment groups and controlled for a number of potentially confounding variables. The study, therefore, was designed to approximate as closely as possible the ideal study described above.

When determining whether to proctor placement tests, institutions will be able to reference the results of my study in addition to other data to support decisions about the administration of placement tests. To contribute to the literature on test modality and inform future decisions about test administration at the study site, the following research questions were investigated:

1. Is there a difference in math course performance in the second math course taken between students who take the math placement test in an unproctored or proctored setting?
2. Is there a difference in the number of semesters in which students persist between students who take the math placement test in an unproctored or proctored setting?

Definitions of Key Terms

The following definitions clarify and standardize the terms used throughout my dissertation.

Computer-Based Testing (also known as technology-based testing; computer-administered test): Assessments administered using computers or other technology-based devices, such as tablets, to disseminate test questions and/or collect test taker responses (*Standards for Educational and Psychological Testing*, 2014). While computer-based testing typically refers to tests administered with a desktop/laptop and keyboard, technology-based testing is a more general term to cover various modes in which tests may be administered (Foster, 2013).

Proctor (also known as invigilators or test administrators): According to *Proctoring Best Practices* (2015), "the proctor is the individual in charge of test administration" (p. 9). This includes enforcing procedures through all phases of the test administration process including pre-, during, and post-test activities, and monitoring test takers during the assessment (*Standards for Educational and Psychological Testing*, 2014). The terms proctor and test administrator are used interchangeably throughout this dissertation.

Proctored Tests: An assessment administered within a setting controlled by a human proctor or tool (i.e., computer application). The human proctor or tool has the responsibilities of a proctor and therefore is responsible for the test administration. See definition for *proctor*. This includes all phases of the test administration process, including pre-, during, and post-test activities. *Proctoring Best Practices* (2015) provides an overview of the proctoring process. In general, a proctored test may include some or

all the following: authenticating a test taker's identity, securing the test taker's environment, and providing information on the test protocol prior to administration. During the assessment, a proctored test is monitored by either a human proctor or computer application. After the assessment, a proctored test is concluded by a proctor by completing any remaining testing protocol.

Standardization: According to *Standards for Educational and Psychological Testing* (2014), standardization in test administration includes "maintaining a consistent testing environment and conducting tests according to detailed rules and specifications, so that testing conditions are all the same for all test takers on the same and multiple occasions" (p. 224). According to *Proctoring Best Practices* (2015), maintaining standardization per the testing protocol is one of the responsibilities of a proctor.

Student Persistence: According to Hagedorn (2012), persistence refers to students' continuation in education, taking into consideration that students rarely progress through education in a linear fashion. For the purposes of this study, persistence refers to students' continuation from one semester to the next at the same institution.

Student Success: Student academic performance is used to measure student success. It is commonly measured by academic indicators such as cumulative undergraduate grade point average and on-time degree completion. In my study, I used final course grade (converted into a 4.0 scale) in math courses as a proxy for student success.

Test Administration Modality: Test administration modality refers to whether the test is administered in a proctored or unproctored setting. See *proctored* and *unproctored* for definitions of each setting.

Unproctored Tests: An assessment administered in a setting without any human proctor or tool (i.e., computer application) responsible for monitoring and thereby controlling the pre-, during, post-test administration activities to ensure testing protocol is being followed. In an unproctored setting, assessments may be administered by providing information to test takers beforehand. Test takers are expected to adhere to testing protocol provided.

CHAPTER 2

LITERATURE REVIEW

Proctoring serves a few functions during test administration. Among others, it helps protect the test from any security incidents and maintain standardization (*Proctoring Best Practices*, 2015). Advances in technology have resulted in test administration moving from a paper to computer-based format, providing the option for unproctored test administration. Research focuses on the implications of proctored or unproctored test administration as well as on the differences of test administration modality in employment and educational settings. However, the literature does not extend to whether there are differences in math course performance and college student enrollment persistence between students who complete a proctored or unproctored math placement test. Since math placement tests are used to assess student academic proficiencies and place them into the appropriate course, it is important to extend the research on these topics to math placement testing.

Employment Testing and Proctoring

There have been several studies on test administration modality within the employment testing sector. Some studies found that unproctored assessments had similar results to proctored assessments (Beaty et al., 2011; Davies & Wadlington, 2006; Templer & Lange, 2008). While these studies suggest there is no significant difference on the validity of the assessment as a result of proctoring, researchers note that the studies may not observe differences of proctoring given how the assessments are potentially used for low-stakes decision making, as these test results are commonly one of many factors

used to determine employment eligibility for entry-level positions. As such, many employers continue to use unproctored, computer-based assessments to screen potential employees, benefiting from the advantages of convenience and efficiency as they can administer the assessment widely to large pools of candidates and save on test proctor costs (Templer & Lange, 2008; Tippins et al., 2006).

Previous research on test administration modalities used in employment testing may help inform further research in educational testing. However, such research should be viewed with caution as the generalizability of employment testing research should not extend to educational testing as the implications of test administration modality on employment and educational tests are not necessarily comparable. That is, the stakes for employment tests may be different from that of educational tests. For example, perceptions of test takers in an unproctored employment setting may be that the tests are low-stakes and are not exclusively used to qualify a candidate for a particular job or determine how much the candidate wants the employment opportunity (Tippens et al., 2006).

Educational Testing and Proctoring

Similar to employment testing, placement tests in educational settings have also transitioned to a computer-based testing format in an unproctored environment. The change to unproctored placement assessment administration is likely driven by convenience and efficiency so that institutions can administer tests to many students with minimal costs. That said, convenience and efficiency must be weighed against effective testing (Jaggars et al., 2013). Although there is some extant literature focused on test

administration modality within employment testing and educational placement tests, there is a lack of literature on the differences of test administration modality during educational placement tests with a process similar to the study site (i.e., uses ALEKS PPL, applied remote proctoring, and online placement administration taken at the convenience of students). Such research is needed to inform decisions such as transitioning from one test administration modality to another.

Placement tests in educational contexts, however, may be perceived as having high stakes, as in many cases the exam is the only metric used to determine whether a student should be placed into developmental or college-level coursework (Scott-Clayton, 2012). In addition, taking developmental courses has been associated with increased time to degree as this adds more courses in the curricular pathway and decreased persistence which could influence students further into perceiving the tests as high stakes (Burdman, 2012). Some areas within the broader testing industry may not be perceived as having as high stakes as placement tests given their attributes (i.e., validity, efficiency, convenience for testing takers, etc.) in which the test is designed. It is important to consider that tests with a balance of specific attributes within the broader testing industry, such as employment testing, may not generalize to those used in higher education given the nature of their use and perceived stakes.

Placement Testing in Educational Settings

Students enter college with a wide range of proficiencies across academic disciplines and fields. Some students enter college academically prepared for college-level coursework while others do not (Bettinger et al., 2013). Because all students are not

academically prepared for college-level coursework, institutions may choose to determine which course each student is prepared to enter as incoming students after admitting them (Barnett & Reddy, 2017). As a result, many institutions administer placement tests to determine whether a student is prepared to enter a particular course (Abraham, 1992; Barnett & Reddy, 2017; Fields & Parsad, 2012; Frisbie, 1982). The results of placement tests are interpreted and used by institutions to predict which course a student is academically prepared to take. Data show that the number of students taking developmental courses is substantial with about 40 percent of students entering four-year institutions taking at least one course at the developmental level (Chen, 2016). Porter and Polikoff (2011) note that if taking a developmental course is an indicator of a student's level of academic preparation, a large portion of incoming students are not academically prepared for college. This suggests that it is due to the variation in academic preparation that a course placement process, such as through placement testing, is necessary to determine which students are academically prepared for college level courses and which are not.

Test Administration Modality in Educational Settings

Research has focused on the differences of test administration modality on exams and overall course grades. Some studies suggest that taking assessments in a proctored setting results in lower test scores and final course grades (Alessio et al., 2017; Daffin & Jones, 2018; Goedl & Malla, 2020; Harmon & Lambrinos, 2008; Prince et al., 2009). However, other studies suggest test administration modality does not result in differences in these outcomes (Beck, 2014; Brallier & Palm, 2015; Ladyshewsky, 2015; Rios & Liu,

2017; Yates & Beaudrie, 2009). It is important to note that these previous studies focus on classroom assessments as opposed to placement tests. The research does not extend to the differences of placement test administration modality and educational outcomes such as cumulative undergraduate grade point average (GPA) or individual course grades. However, a pilot study on proctored placement tests found that a significantly greater percentage of students taking a placement test in a proctored setting were placed in one course level lower than students who took the placement test in an unproctored setting (Martin et al., 2019). In addition, the average final grade in the initial math course of students enrolled in courses into which they were placed from a proctored assessment was significantly higher than the grades of students who took the placement test in an unproctored setting

Test Administration Modality and Academic Performance

Findings from previous studies do not consistently agree that there is a difference in academic performance and other educational outcomes between students who take tests in a proctored or unproctored format. For example, Alessio et al. (2017) separated students in an online course into two groups: one group took proctored assessments, and the other group took unproctored assessments. Alessio et al. found higher test score performance among those who completed proctored exams. In addition, higher student attrition was observed in the course with proctored tests than the course without proctored tests. Similarly, Goedl and Malla (2020) found significant differences in scores for multiple exams between proctored and unproctored groups with the unproctored group usually scoring higher on average than the proctored group. They also found that

course grades were higher for unproctored students. If studies suggest that there are differences in outcomes for classroom exams and final course grades, between proctored and unproctored assessments, there is reason to believe that there are differences in student placement levels and between proctored and unproctored placement tests. The pilot study explored these differences and offered an opportunity to understand the differences in math course performance beyond the first semester and college student enrollment persistence between students who complete a proctored or unproctored placement test.

Math Course Placement, Performance, and Persistence

Research suggests that one in four test-takers are misplaced in math courses (Scott-Clayton et al., 2014). Given the implications of misplacement, this raises course placement as an issue of interest. Saxe and Braddy (2015) share concerns about the status of undergraduate math education with many students not performing well in undergraduate math courses. Among other notable statistics, they identified that only half of students earn a "C" or higher in College Algebra (Ganter & Haver, 2011; Saxe & Braddy, 2015). In addition to other areas, Saxe and Brady suggest that "traditional placement" between secondary and postsecondary institutions is impacting performance in undergraduate math courses. Improved course placement practices could improve performance in math courses.

Although there is limited research on whether there are differences in math course performance and college student enrollment persistence between students who complete a proctored or unproctored placement test, there are variables, such as initial math course

performance (a proxy for math proficiency), gender, and race that could lead to differences in student performance in a student's initial and subsequent math courses. Regarding math proficiency and first semester math course grade, Van Dyken et al. (2015) suggest that for engineering students, first math course grade, course level, and student gender were predictors of student persistence with first math course grade and course level predicting persistence at a significant level. Using data from the National Assessment of Educational Progress, Lubienski (2001) suggests that race and gender account for part of the math achievement gap with race far outweighing gender in significance. Although information about these differences in achievement has existed for decades, gaps in math achievement persist among student groups. As such, it is important to account for students' demographic characteristics when predicting achievement in math courses to control for factors that may directly correlate with academic success.

Cheating and Test Standardization

With advances in technology, test administration has changed in modality from paper-based to computer-based tests. In addition to this transition, Foster (2009) suggests that organizations have also made the decision to administer unproctored tests to distribute them in the most widely accessible format possible to an increasingly large number of test takers (as cited in Wollack & Fremer, 2013). The decision to administer unproctored tests, however, must coincide with compelling evidence that the reliability and validity of the assessment remain unchanged. Reliability and validity are some of the foundational principles of testing according to the *Standards for Educational and Psychological Testing* (2014). Therefore, maintaining test reliability and validity are

major considerations in the testing process, particularly when making decisions about test administration modality (*Standards for Educational and Psychological Testing*, 2014). If the validity of a test is weak, meaning that the test results do not measure what the test intends to measure, the results of the test cannot be used with confidence to make meaningful conclusions, thereby rendering the test useless. Placement tests and their results need to have strong validity to be used with confidence (Morante, 1987; Scott-Clayton, 2012). Moreover, if the reliability of a test is weak, the test cannot be used with confidence to produce consistent results.

The reliability and validity of a given test may be compromised in a variety of ways because of test administration processes and protocol. One way that this may happen through the test administration process is cheating such as using unpermitted resources. Cheating on educational tests has been well-studied and the phenomenon of cheating does not appear to be in decline (Dyer et al., 2020; McCabe et al., 2001; McCabe & Treviño, 1997). Cheating also continues to be an issue regardless of changes in test administration modality, and methods used to cheat advance with technology. The *Handbook of Test Security* (2013) suggests that cheating methods evolve with advancements in test delivery methods, reinforcing the need for test security prevention and cheating detection methods. Test takers also have greater access to cheating methods than in the past. There are a variety of technological resources that could help test takers gain an unfair advantage. Perhaps the most widely known and utilized unpermitted resource is the internet, which not only contains a wealth of information for test takers,

but also instantly connects test takers to individuals who can provide outside help on test content.

Proctoring is one way test security can be enforced to prevent cheating. Woodruff (2013) identifies proctoring as "the most important security related activity in which the instructor will be involved" during classroom testing (p. 94). Proctors are charged with the responsibility to "maintain integrity and security during the test process" (ATP & NCTA, 2015, p. 9). Since previous research suggests that students may perceive academic dishonesty differently depending on test administration modality, it is possible that proctoring is still needed to protect the administration process and test content (Dyer et al., 2020). Without proctoring, the reliability and validity of the test could be compromised by individuals cheating during the test and therefore gaining an unfair advantage that would affect the interpretability of the results.

Just as cheating can affect the validity of test results, the lack of standardization during the test administration process can create an unfair advantage for test takers and result in unreliable results due to variance of the scores, which threaten the test's validity. Examples of ways that inconsistent test administration can create unreliable results is through cheating, unclear instructions, or inconsistent testing environments. If students are completing assessments with inconsistent test administration, there could be greater variance amongst their scores and therefore the scores could be unreliable or invalid. Among others, Haladyna (2006) identifies test administration as one area of risk in achieving validity in testing as the test administrators themselves may not administer the test in a standardized way whether purposefully (e.g., giving extra time or reading

questions out loud to test takers) or by accident (e.g., administrators may not be fully sure whether they are administering the assessment accurately; Haladyna et al., 1991). If testing protocol is not followed, it is the responsibility of test administrators to document and report any deviations from testing protocol so that the test developer and test users may determine whether the results can still be used (ATP & NCTA, 2015; *Standards for Educational and Psychological Testing*, 2014).

Proctoring can affect both cheating and standardization. Proctors are responsible for maintaining test security, preventing cheating, and maintaining standardization by adhering to test specifications and protocol (ATP & NCTA, 2015). The *Standards for Educational and Psychological Testing* discusses the need for test administrators during the test administration process to help maintain the reliability and validity of test scores, stating that "the usefulness and interpretability of test scores require that a test be administered" (p. 111). The standards on test administration emphasize the need for standardization and test security.

ALEKS Assessment

The institution at which this study was conducted used Assessment and Learning in Knowledge Spaces (ALEKS) Placement, Preparation and Learning (PPL) as the assessment for math proficiency. Efficacy studies have been conducted on the ALEKS PPL product, comparing it to other placement methods, which include success in students' first math course taken and persistence. A case study marketed by McGraw-Hill at Harper College, comparing student math course performance and likelihood of persistence between ALEKS and ACT Compass (an alternative placement test), suggests

that students who were placed using ALEKS were more likely to earn a "C" or better and were more likely to enroll at the institution for a second semester ("ALEKS PPL Significantly," n.d.). The findings do not necessarily mean that ALEKS is a better placement tool than ACT Compass but could mean that the cut scores used for ACT Compass were too low.

Other institutional case studies share similar results with higher success rates and lower DFW rates for students when comparing ALEKS to the institution's prior placement methods ("ALEKS PPL Provides", n.d.; "Iowa Central Community College", n.d.). None of the case studies, however, address proctored versus unproctored ALEKS placement assessments. The case studies within the institutions vary in proctoring requirements for the assessments, as ALEKS allows institutions to customize proctoring requirements for each student attempt. The result is any combination of proctored or unproctored placement tests with some institutions permitting the first session be unproctored followed by proctored retests, some permitting all unproctored sessions and others requiring all sessions be proctored. Therefore, the case studies do not provide conclusions about the differences of test administration modality on math course performance and student persistence.

Limitations and Gaps in the Literature

Proctoring is one method to prevent cheating and maintain standardization during tests so that test results can be interpreted and used with confidence. Prior research has revealed pronounced limitations and gaps in understanding the outcomes of proctoring in educational testing and on placement test results. The effects of test administration

modality on classroom exams and employment assessments are well-studied. It is important to research the differences of test administration on different types of educational assessments, not just classroom exams. The literature discussed in this chapter suggests the many ways placement assessments are different from other assessments, such as how the results are used and how test takers perceive them (e.g., high-stakes versus low-stakes). As a result, it cannot be assumed that the findings of research on classroom exams are generalizable to placement tests. The second limitation or gap in the literature is the need to understand whether there are differences in academic outcomes between students who completed proctored and unproctored placement tests. Case study research on ALEKS PPL as a math placement assessment demonstrates positive academic performance and outcomes for institutions that use it.

However, the case studies do not address the proctoring requirements used at the institutions, which vary between unproctored for all attempts, proctored for all attempts, and a mix of unproctored or proctored throughout the attempts. The current study addresses these limitations and gaps by exploring whether test administration modality during placement tests moderates the relationship between math course placement and math course performance and number of semesters in which students persist.

CHAPTER 3

METHODOLOGY

In the current study, I investigated if students who took the math placement test while being proctored obtain different grades in their second math course and have greater retention compared to students who took the math placement test unproctored by examining final course grades along the math course sequence (as identified in Table 3.1) and in student persistence (number of semesters in which students persist) between proctored and unproctored groups. The null hypothesis was that there is no difference in subsequent math course performance and number of semesters in which students persist between students who took a math placement test in an unproctored or proctored setting. To reject or fail to reject the null hypothesis, I analyzed data collected from students enrolled at a large, urban institution located in the Mid-Atlantic region of the United States who completed a math placement test with or without a remote proctoring service. The data analyzed were provided by the institution's research and assessments office for the 2018-2019, 2019-2020, 2020-2021 academic years.

Pilot Study

In 2018, I conducted a pilot study with colleagues to analyze (1) whether there are differences between math course placement levels between proctored and unproctored placement tests and (2) if proctored students achieved higher final grades in initial math courses compared to unproctored students. Findings from the pilot study show that students tend to place about one math course level lower (less advanced) when placed with a proctored math placement test (Martin et al., 2019). Proctored students had higher

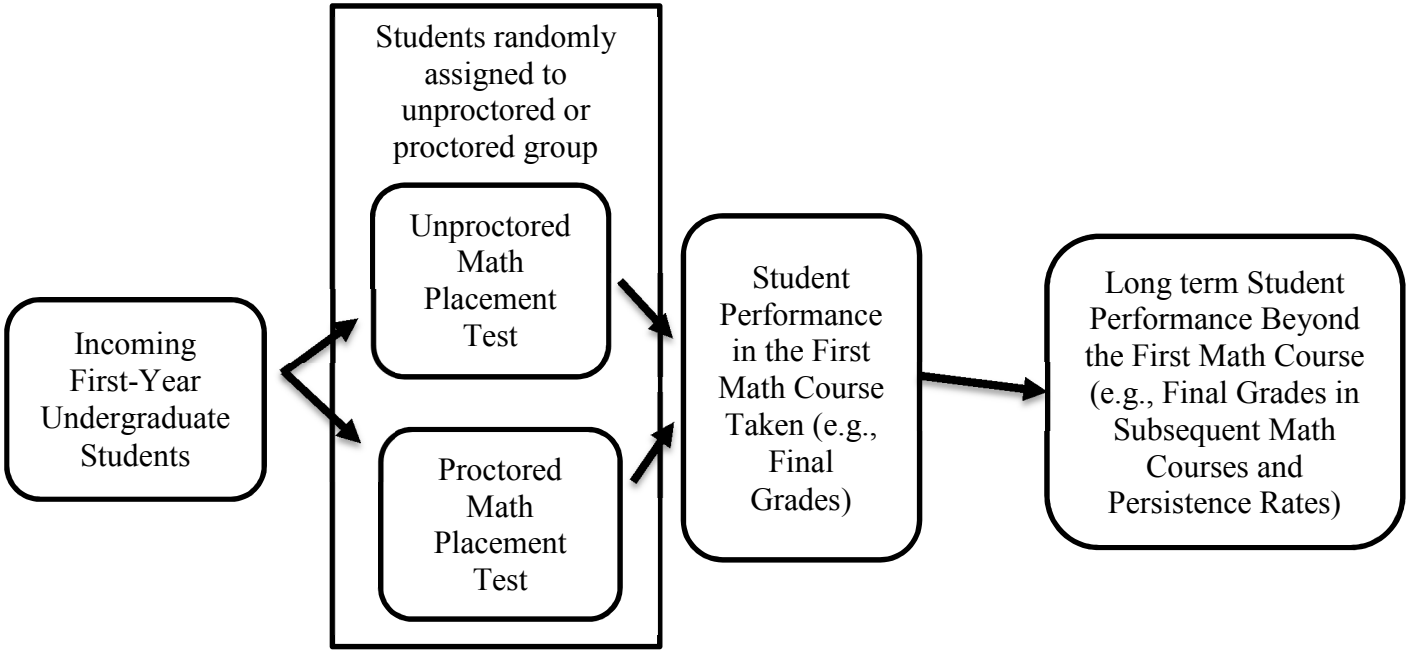
course grades than unproctored students. Three full academic years have passed since participants in the pilot study completed a placement test, which provided necessary data to explore the current research questions given their longitudinal nature.

Current Study

Figure 3.1 presents a model of chronological events for my current study. In the model, incoming first-year undergraduate students are randomly assigned to the unproctored or proctored math placement test group. As depicted in the model, the proctoring condition (proctored or unproctored) acts as the predictor variable with final grade in the initial math course taken as an immediate short-term outcome variable and final grades in subsequent math courses and persistence as outcome variables beyond the initial math course. In the study, I control for student-level variables such as math proficiency (i.e., initial math course GPA) and student demographics (i.e., gender and socioeconomic status), which could correlate with student performance in math courses.

Figure 3.1

2018 Pilot Study Model and Proposed Study Outcomes



Prior to 2018, the participating institution administered unproctored math placement assessments. The implementation of proctored and unproctored math placement assessments coincided with the administration of placement assessments, which began at the participating institution in April 2018 for the Fall 2018 incoming first-year undergraduate cohort and concluded within the first two weeks of classes during the fall semester (early September 2018). To address the research questions, I used a quantitative approach to understand whether there are differences in math course performance and college student enrollment persistence between students who completed a proctored or unproctored math placement test. The institution retains data on all student placements including, but not limited to, automatic placement information, whether a math placement test was required, whether the test was proctored or unproctored, number of placement tests taken, and the resulting course placements from each test attempt. Student placement information in conjunction with additional academic performance and demographic information was requested from the participating institution's research and assessment department.

After I received the raw data from the institution, I used statistical techniques to analyze the data and answer the research questions within the current study. Prior to answering the research questions, I analyzed the data to report on the descriptive statistics of the populations and presented the results of inferential statistical analyses (the analysis of variance and multivariate correlations) to contextualize my findings.

Using a quantitative approach to answer the research questions about test administration modality is logical given that placement tests are designed for making predictions about students' preparedness for specific coursework. Since my current study

used a population of students across a variety of majors from a large, public institution, the design of my research study supports repeatability and generalization to similar populations (i.e., large, diverse incoming freshmen cohort) if statistical assumptions and statistical significance are met (Mertens, 2020). One of the statistical methods used to address the research questions, hierarchical linear regression, provided several advantages over other statistical methods. Regression analysis enabled the study of the effects of multiple predictor variables on the identified outcome variables to understand how the predictor variables are related to the outcome variables. This is particularly critical in my current study which has identified several covariates that may impact student performance and persistence beyond the first semester.

Participants

In my study, I used data from the 2018 cohort of first-year incoming undergraduate students at a large, urban public institution in which students were randomly assigned to a proctored or unproctored group to complete a math placement assessment. The sample for analysis from the 2018 cohort excluded transfer students, students who satisfied math requirements based on transfer credits, and students who automatically placed based on their standardized admission test scores into Calculus (the highest course placement). Those students who were placed into the highest level of math using SAT/ACT scores that the placement process could place them into or satisfied the institution's math requirements based upon previous coursework were not required to take the placement test. Therefore, these students could not be included in the study. Students placed into Calculus through the placement test were included in the study since they took the placement test and would likely take the course, which is necessary data for

the study. For logistical reasons, graduate and professional students, students enrolled at international campuses, and students who required test accommodations were also excluded.

Students were assigned to either the proctored or unproctored group. The default assignment is the unproctored group. Students were assigned to the proctored group using a proportional stratified random sampling strategy, stratifying on major (STEM[2] major versus non-STEM major) and auto-placement status (auto-placed versus not auto-placed; Martin et al., 2019; Sharma, 2017). The intent of this sampling strategy was to include a variety of students in the study including those across academic schools and colleges within the institution since all students regardless of the school or college in which they are enrolled at the study site are required to have a math course placement on their record unless exempt based upon transfer credits. The groups included larger populations of students who were not automatically placed into math courses and who were admitted into STEM majors as these students were more likely to take a math placement test and math course in their first semester, which is why proportionate stratified sampling was used (Mertens, 2020). The sizes of the two groups were determined based on the proportions of STEM and non- STEM majors in the previous incoming class. Some students were assigned to the proctored group, but ultimately did not take a test. This included students who either already received an automatic course placement because of their SAT/ACT scores and therefore did not choose to test or students who decided not to enroll at the institution.

[2] The institution defines STEM majors as any major that requires College Algebra or higher level.

Procedures

My current study used data from the fall 2018 math placement test administration. At the time of administration of the math placement assessment, the institution's incoming students were placed into math courses via one of two ways: (1) automatic placement into a math course based upon SAT/ACT math scores or (2) completion of an online placement assessment through McGraw Hill's ALEKS PPL system. Tables 3.1 and 3.2 outline the math courses that students may be placed into (Table 3.1) and the automatic course placement brackets (Table 3.2).

Students may be placed into math courses based on SAT/ACT math scores taken within two years of their matriculation date. Students who received an automatic course placement were given the option to take an ALEKS assessment if they did not feel that their auto-placement was representative of their math knowledge. Students with SAT/ACT test scores between 500 and 550/18 and 22 and students admitted through a test-optional pathway were required to complete the ALEKS assessment. Therefore, not all incoming first-year undergraduate students were automatically placed based on SAT or ACT math scores. Students who did not receive an automatic math course placement were required to take the assessment with ALEKS prior to registering for classes so that a math course placement was on each student's record. Test-optional students were required to take an assessment and were not auto-placed even if SAT or ACT math scores were on the student's record that would result in an automatic course placement. Students placed via either method (i.e., auto-placement or ALEKS placement test) could take ALEKS up to three times. However, to receive the option to take the assessment a second and third time, students were to complete at least five hours of training in ALEKS Prep

and Learning Modules between their first and second attempts and their second and third attempts.

The placement procedures permitted students to seek a different course placement if they were willing to take the ALEKS test or, if they had already tested, complete time within an ALEKS learning module and retake the test. Students who sought a different course placement may have qualities that distinguished them from students who did not choose to pursue a different course placement. For example, students needed to be aware of their placement options and motivated to spend time to take an assessment. The initial pilot study findings suggest that students in STEM majors retook the ALEKS test at higher rates than students enrolled in non-STEM majors, which could possibly be due to their programs requiring more math courses compared to the other majors.

Table 3.1

Math Course Placements

Course Name	Description
Pre-College Math Course	Developmental math course; Part of the math course sequence
General Education- Quantitative Literacy	General education course
College Algebra	Part of the math course sequence
Pre-Calculus	Part of the math course sequence
Calculus	Part of the math course sequence
Statistics Levels 1 and 2	Primarily taken by students in the business school

Note. Pre-College Math Course, College Algebra, Pre-Calculus, and Calculus are a part of the math course sequence.

Table 3.2

Math Auto-Placement Chart

	SAT Scores	ACT Scores	Course Placement
Highest SAT Math/ACT Math score is less than or equal to	490	17	Pre-College Math Course
Highest SAT Math/ACT Math score is between	500 and 550	18 and 22	A Math Assessment is required.
Highest SAT Math/ACT Math score is equal to or greater than	560	23	General Education – Quantitative Literacy, Statistics Level 1
Highest SAT Math/ACT Math score is equal to or greater than	650	28	Statistics Level 2
Highest SAT Math/ACT Math score is equal to or greater than	700	31	Calculus

Note. Students with a SAT/ACT score between 500 and 550/18 and 22 are required to take a math placement.

Implementation of Proctoring

To implement proctoring for the study, the ALEKS math placement test was administered with remote proctoring through ProctorU. Upon submitting a tuition deposit to matriculate at the institution, incoming students accessed the math placement test within their student portal. The student portal contains a communication channel that populates with required and optional placement tests available to students. To complete the ALEKS test, both the proctored and unproctored groups clicked on the task to complete ALEKS in the communication channel. After clicking on the task, students were taken to a new webpage with specific information about next steps that

corresponded to the student's assignment to the proctored or unproctored group. Students assigned to the unproctored group were required to read the webpage contents and acknowledge the institution's code of conduct. At the bottom of the page, students clicked on an icon to agree to the terms of the test and were then redirected to the ALEKS test site. Students in the unproctored group then proceeded to take the assessment.

Students assigned to the proctored group were given directions to create an account with ProctorU, a remote proctoring service, and schedule a test appointment. Students then returned to their student portal at the time of their test appointment and clicked on the task to complete their ALEKS test. Students then proceeded to the bottom of the page to acknowledge the institution's code of conduct. Students in the proctored group proceeded to take the assessment with their proctor. These students were unable to proceed to take the assessment until they were connected to a proctor who would input a password to start the assessment at the time of their appointment. Students in the proctored group completed their assessment with ProctorU at a "Live Launch, Record, & Review" service level. During the test appointment, students connected with a virtual, human proctor using a webcam with audio. The proctor completed pre-, during, and post-test administration activities, including authenticating the student's identity, securing the test environment, and launching the exam using the proctor password. Once the exam was launched, the test appointment was then recorded without the virtual, human proctor. Upon completion of the test appointment, ProctorU used a combination of artificial intelligence and human review to review the recorded test sessions and notified the institution of any incidents in which the student did not adhere to testing protocol. If an incident was identified, the institution reviewed the situation further to determine if

action was required, such as invalidating the assessment for not adhering to testing protocol. If a result was invalidated, students were required to retake the test so that a valid placement result was available for them. Invalidated results were excluded from the study. Students in both the unproctored and proctored groups were informed of the potential use of data for the research study and were permitted to opt out of the study. Ultimately twenty-one students who were originally assigned to the proctoring group were moved to the unproctored group due to a variety of reasons related to implementation, such as issues with securing or setting up the technology required.

Variables

The data requested from the institution included the de-identified data corresponding to the variables indicated in Appendix A such as student demographic characteristics (i.e., race, gender, and Pell Grant status), academic information (i.e., SAT/ACT math scores, high school GPA, college and major at time of admittance, change of major (if applicable), semester by semester GPA, initial and second math course taken for courses along the math course sequence [Pre-College Math, College Algebra, Pre-Calculus, and Calculus], and student status [e.g., full-time, part-time, etc.]) and course placement results (i.e., auto-placement course placement results, test administration modality assignment, ALEK scores, and ALEKS course placement results). Some of the data requested were used as covariates in the analysis including factors such as a student's gender and GPA from the initial math course taken to control for the possible effects these variables may have on the outcome variables. Since the factors identified were hypothesized to be correlated with student performance and

persistence, it was important to control the significance of their prediction of the outcome variables.

Predictor Variables

Prior research on the differences of proctored and unproctored assessments in educational settings are inconclusive as some studies suggest that test administration modality results in lower academic performance, such as test scores, while other studies suggest that there is no difference on academic performance because of test administration modality. In addition, there is limited literature available on whether there are differences in math course performance and college student enrollment persistence between students who completed a proctored or unproctored placement test. Test administration modality, proctored or unproctored testing, served as a dichotomous predictor of student performance in math courses and student persistence to identify if there is a difference in academic performance and student persistence between student groups based upon test administration modality during placement tests.

Outcome Variables

The outcome variables in the current study included student performance in math courses and student persistence. The GPA students earned in their second math course taken served as the math course performance variable. I only used course-level grade information provided by the institution given the math courses identified in Table 3.1. Only math courses within this sequence of courses were included as the curricula proceed linearly for students to complete them. Students who do not complete a second math course within one year of completing their initial math course were removed from the study. Students who repeated courses in the math course sequence and therefore have two

final grades in these courses were identified, and only the grade from the initial attempt was included as students who have taken a second attempt will be either reflected as a withdrawal from the course or failing grade from their initial attempt. In addition, students that take a second attempt have had prior exposure to course materials, which impacts their second attempt.

The student persistence variable is operationalized in two ways. One way is the number of consecutive semesters in which a student is enrolled at the institution. The other is the total number of semesters completed, which included students who do not complete consecutive semesters of coursework. This variable was calculated using transcript information provided by the institution.

Covariates

Based on the literature, I included several covariates in the regression model. The correlation coefficients for all study variables are presented using a correlation matrix. Covariates included for the study are student demographics (i.e., gender and socioeconomic status) and math proficiency (initial math course GPA). I used institutional data to determine student demographic characteristics. For students' socioeconomic status, I used Pell Grant status as an indicator for family income status.

Data Analysis

After completing the procedures above, I imported the dataset into SPSS for further analysis. I used descriptive statistics to explore the group characteristics between proctored and unproctored students. For this part of the analysis, I compared groups based upon SAT/ACT math scores, high school GPA (HSGPA), and demographic

characteristics (i.e., gender and socioeconomic status). I then addressed each research question using ANOVA and regression analysis.

Research Question #1: Differences in Student Performance in Subsequent Math Courses between Students Who Completed Proctored or Unproctored Placement Tests

To address the first research question that asks if there is a difference in performance in second math course taken between students who take a proctored placement test and students who take an unproctored placement test, two analyses were conducted. First, the grades in the second math courses were compared through ANOVA. To extend this analysis the grades that a student obtained in the second math course were obtained if the second math course was taken one semester or two semesters after the initial course. Second, a hierarchical linear regression model was developed that included the following blocks of variables: (1) student's demographic characteristics (i.e., SAT Math, gender, high school GPA, socioeconomic status), (2) math proficiency (initial math course GPA), and (3) test modality. In the analysis, I applied the covariates first to determine if test administration modality is a statistically significant predictor of math course performance over and above the covariate variables.

Research Question #2: Differences in Student Persistence between Students Who Completed Proctored or Unproctored Placement Tests

To address the second research question that asks if there is a difference in student persistence between students who take a proctored placement test and students who take an unproctored placement test the percentages of students who were retained in the two conditions were compared using chi square.

Conclusion

The purpose of my current study was to determine if there are differences in math course performance and student persistence between students who take a proctored placement test and students who take an unproctored placement test. A 2018 pilot study provided preliminary information on the differences of test administration modality on math course performance and informed the research design and methodological approaches for this study.

CHAPTER 4

RESULTS

This chapter presents the results of the quantitative analyses described in Chapter 3, including descriptive statistics and results that address the research questions of the pilot study and current study.

Current Study

The purpose of my study was to examine if there are differences in math course performance for second math courses taken and college student enrollment persistence between students who completed a proctored or unproctored math placement test. A pilot study was conducted in which an incoming cohort of first-year undergraduate students for fall 2018 were assigned to a proctored or unproctored condition to complete their math placement test. Data were collected from the fall 2018 cohort, including but not limited to placement scores and final grades in their initial math course taken. The pilot study analyzed whether there are differences between math course placement levels between proctored and unproctored placement tests and if students who completed a proctored test achieved higher final grades in initial math courses compared to students who completed an unproctored test. I analyzed data from the pilot study as well as additional data to answer the research questions.

Description of Dataset

I analyzed de-identified admissions, demographic, academic, and course placement data from the fall 2018 first-year admissions cohort. Information was collected from student admission applications and institutional records. The information gathered from student admission applications includes nominal data, such as admission type (e.g.,

early decision, test-optional), and continuous data, such as high school GPA. The admissions application, in part, relies on students' interpretations and self-reporting, such as how a student responds to a question asking about their gender. Institutional records include placement information (e.g., automatic placement information, ALEKS scores, and course placement results) and academic information (e.g., college program and math courses taken along with final grades).

I made several decisions about the use of some of the information gathered. For example, the pilot study included an analysis of data from incoming fall 2018 students who completed an assessment. The primary focus of the pilot study was on the initial math course taken in the fall semester. Information about which exact students were included in the study was not readily available given that the research team that conducted the pilot study has moved on from their prior roles. As such, I replicated the pilot study, which affirmed the same findings with some small variations. When I replicated the study, I also included students whose initial math course was in the spring of 2019 as these data were not available at the time of the initial pilot study. This decision resulted in a larger study sample, but still produced similar findings as the pilot.

I made several additional decisions regarding the use of the information gathered. This included not using the honors Calculus section within the dataset except for a couple of secondary analyses. It is assumed that students within the course are inherently different because honors students are likely to exhibit different characteristics than other students, such as higher levels of motivation. In addition, the number of students in honors Calculus is too small to come to any significant conclusions. Another decision was to merge courses at the pre-college level for analysis, unless otherwise noted. At the

institution, two courses are offered at the pre-college level; one for students who require higher levels of math for their program and one for students who do not. For the purposes of my study, if students' initial math course was at the pre-college level, then my analysis examines the next course taken along the institution's math course sequence. This means that most students in my analysis were students who require higher level math courses as the next course in the sequence is college algebra. My analysis did not include students who retook the course because those who retake courses may have exposure to course material from their initial attempt. Therefore, students who retook the same course were not included in the study.

Descriptive Statistics

Descriptive statistics show the group characteristics of the entire fall 2018 admission cohort compared to my study sample as well as the distribution of test administration modality among the students in my study sample. There were 5,030 students included in my dataset. Of the 5,030 students, 2,204 are included in the study sample for test administration modality. Table 4.1 presents a comparison of my study sample to the total admissions cohort.

Students identified as one of eight categories for race/ethnicity, including Black or African American, American Indian or Alaska Native, Asian, Hispanic or Latino, International, Multiple Races (i.e., two or more races), Pacific Islander, or White (non-Hispanic). Within the total admissions cohort, data were missing for 68 students. Within the study sample, data were missing for 23 or 1.0% of the study sample). Table 4.1 includes the frequency and percent of category for the total admissions cohort and study sample, which further summarizes race/ethnicity for participants between the proctored

and unproctored groups. Categories within my study sample are similar to the total admissions cohort except for African American, Asian, and White racial/ethnic categories in which there is more than one percentage point difference between the total admissions cohort and study sample (3.8% more African American students, 4.0% more Asian students, and 8.3% less White students). African American, Hispanic, and White students comprise a larger percent of the proctored group compared to unproctored students (16.0% versus 15.6%, 12.3% versus 9.1%, and 51.2% versus 48.3% respectively).

Table 4.1

Race/Ethnicity for Total Admissions Cohort and Study Sample

	Total Admissions Cohort		Study Sample			
			Proctored		Unproctored	
Race/Ethnicity	Frequency	Percent of Admissions Cohort	Frequency	Percent of Sample	Frequency	Percent of Sample
African American	601	11.9	86	16.0	260	15.6
American Indian	1	0	0	0	0	0
Asian	629	12.5	74	13.8	290	17.4
Hispanic	451	8.9	66	12.3	152	9.1
International	192	3.8	10	1.9	62	3.7
Multiple	209	4.1	18	3.4	80	4.8
Pacific Islander	4	.1	0	0	3	.2
White	2,895	57.3	275	51.2	805	48.3
Missing	68	1.3	8	1.5	15	.9

Students identified as one of three categories for gender, including female, male, or not indicated. Within the total admissions cohort and study sample, this information was missing for one of the students (.01% of the total admissions cohort). Table 4.2 includes the frequency and percent of each category for the total admissions cohort and study sample. Categories within my study sample are similar to the total admissions cohort. More females were included in the proctored group compared to the unproctored group (60.6% versus 54.9%).

Table 4.2

Gender for Total Admissions Cohort and Study Sample

	Total Admissions Cohort		Study Sample			
			Proctored		Unproctored	
Gender	Frequency	Percent of Admissions Cohort	Frequency	Percent of Group	Frequency	Percent of Group
Female	2907	57.8	325	60.6	915	54.9
Male	2120	42.2	211	39.4	751	45.1
Not Indicated	2	.01	1	.2	1	.1

My dataset provides information indicating whether students received a Pell Grant or not. The Pell Grant is used as a proxy for socio-economic status. Table 4.3 shows the frequency and percent of students who received or did not receive a Pell Grant. The number of students who received a Pell Grant is slightly higher in my study sample (34.9%) than in the total admissions cohort (28.8%). The percent of students who

received and did not receive a Pell Grant are distributed similarly between proctored and unproctored groups.

Table 4.3

Pell Grant Status for Total Admissions Cohort and Study Sample

	Total Admissions Cohort		Study Sample			
			Proctored		Unproctored	
Pell Grant	Frequency	Percent of Admissions Cohort	Frequency	Percent of Group	Frequency	Percent of Group
No	3,594	71.2	351	65.4	1984	65.0
Yes	1,456	28.8	186	34.6	583	35.0

My dataset included information regarding SAT/ACT Math scores and High School GPA. Table 4.4 shows the mean for each. For SAT Math, the mean score is a few points less in my study sample (606.22) compared to the total admissions cohort (610.48). For ACT Math, the mean score is similar between my study sample (25.29) compared to the total admissions cohort (25.44). High School GPA is exactly the same between the total admissions cohort and my study sample.

Table 4.4

SAT Math, ACT Math, and HS GPA, Mean and Range for Total Admissions Cohort and Study Sample

	Total Admissions Cohort		Study Sample	
	Mean	Range	Mean	Range
SAT Math	610.48	290 – 800	606.22	290 – 800
ACT Math	25.44	14 – 36	25.29	14 – 35
High School GPA	3.59	1.70 – 4.0+	3.59	2.1 – 4.0+

Table 4.5 presents the mean and range for SAT/ACT Math scores and high school GPA. The table suggests that the proctored group consisted of students with a lower mean SAT math score (578.91 versus 614.50) and ACT math score (24.10 versus 25.59) compared to those in the unproctored group.

Table 4.5

SAT Math, ACT Math, and HS GPA, Mean and Range within the Proctored and Unproctored Group

	Total Admissions Cohort		Proctored		Unproctored	
	Mean	Range	Mean	Range	Mean	Range
SAT Math	606.22	290 – 800	578.91	350 - 690	614.50	290 – 800
ACT Math	25.29	14 – 35	24.10	14.30	25.59	14 – 35
HS GPA	3.59	2.1 – 4.0	3.59	2.27 – 4.0	3.59	2.1 – 4.0

Students may apply to the institution as standard applicants or through the institution's test-optional admissions policy. Table 4.6 shows the frequency and percent of students admitted through either admissions type. My study sample includes 4.2% less

standard admits than the total admissions cohort (78.1% versus 82.3%). Test-optional students comprise more of the proctored group than the unproctored group (27.9% versus 20%). The institution's placement process permits standard admits with standardized test scores to automatically place into courses rather than take placement tests.

Table 4.6

Admit Type for Total Admissions Cohort and Study Sample

	Total Admissions Cohort		Study Sample			
			Proctored		Unproctored	
Type	Frequency	Percent of Admissions Cohort	Frequency	Percent of Group	Frequency	Percent of Group
Standard	4,156	82.3	387	72.1	1.334	80.0
Test-Optional	894	17.7	150	27.9	333	20.0

Table 4.7 shows the frequency and percent of students within each academic school or college at the time of admission to the institution. My study sample reflects larger quantities of students enrolled in STEM related majors, such as engineering (12.5% versus 6.2%) and science (38.9% versus 18.6%) compared to the total admissions cohort. Between proctored and unproctored groups, the percentage of students that make up the unproctored group is higher in engineering (13.4% versus 9.9%) and science (40.9% versus 32.6%).

Table 4.7

Makeup of School/College for Total Admissions Cohort and Study Sample

	Total Admissions Cohort		Study Sample			
			Proctored		Unproctored	
School/College	Frequency	Percent of Admissions Cohort	Frequency	Percent of Group	Frequency	Percent of Group
Music and Dance	128	2.5	6	1.1	8	.5
Business	845	16.7	44	8.2	143	8.6
Theater and Film	184	3.6	6	1.1	13	.8
Media and Communication	330	6.5	16	3.0	16	1.0
Education	112	2.2	11	2.0	25	1.5
Engineering	312	6.2	53	9.9	223	13.4
Public Health	545	10.8	84	15.6	217	13.0
Liberal Arts	788	15.6	70	13.0	159	9.5
Science and Technology	941	18.6	175	32.6	682	40.9
Social Work	18	.4	2	.4	3	.2
Art and Architecture	249	4.9	17	3.2	25	1.5
Sports, Tourism and Hospitality	226	4.5	16	3.0	44	2.6
General Studies	372	7.4	37	6.9	109	6.6

Note: List of school/college reflects academic areas rather than actual school/college name to protect anonymity.

Summary of Descriptive Statistics

Overall, the descriptive statistics show that the admission cohort and my study sample are comparable with two exceptions. First, my study sample includes more students from engineering and science colleges compared with other academic schools and colleges at the study site. As mentioned in Chapter 3, this was an anticipated difference as the sampling strategy was proportionate stratified sampling on academic major, which resulted in a greater number of students in STEM majors in my study sample. This was an intentional decision to assign students to the proctored group who are likely to take the math placement assessment and to increase the likelihood that students who take the math placement assessment will also take the math course in which they were placed. Both decisions were necessary to collect the relevant data. The second difference is that my study sample has a lower cumulative GPA compared to the total admissions cohort. The difference in cumulative GPA could be the result of the admission or placement process and decisions made in identifying the study sample. For example, the admission process at the study site gives students the option of applying by submitting standardized test scores or as test-optional. Students with standardized test scores may be automatically placed into math courses while students admitted as test-optional will be required to complete a placement test. Students with lower admissions test scores may be less likely to submit them, which could result in students with lower math proficiency being required to take the placement assessment. It will be important to keep these differences in mind when interpreting the results of the study.

Initial Pilot Research Question Analysis

The initial pilot study completed in 2018 focused on two major research questions:

1. Is there a significant difference in placement level as a function of proctored versus unproctored testing?
2. Is there a significant difference in student performance in math courses as a function of proctored versus unproctored testing?

Since my dataset includes both fall 2018 and spring 2019 course grade information, the analysis for the current study replicates similar results to the initial pilot study but analyzes an additional semester of data. Regarding the first research question, remote proctoring had a significant effect on ALEKS assessment performance, with students typically placing one math course level lower compared to an unproctored placement test. Table 4.8 presents the mean ALEKS score for the proctored group compared to the unproctored group for the first, second, and third most recent ALEKS attempt along with the significance level and partial eta squared, which is the effect size commonly used in ANOVA designs. According to Maher et al. (2013), partial eta squared can be interpreted as follows: small = .01; medium = .06; large =.14.

Table 4.8

Mean ALEKS Score by Most Recent Attempt for Proctored and Unproctored Group

	Mean for Proctored	Mean for Unproctored	F	Significance	ηp2
Most Recent ALEKS Attempt	41.56 (*n* = 653)	55.87 (*n* = 2,087)	216.47	.000	.096
Second Most Recent ALEKS Attempt	41.70 (*n* = 170)	44.34 (*n* = 368)	2.55	.111	.005
Third Most Recent ALEKS Attempt	43.94 (*n* = 50)	44.19 (*n* = 53)	.006	.941	.000

As shown in Table 4.8, there is a statistically significant difference in mean ALEKS scores between the students in the proctored and unproctored groups with a medium to large effect size for the most recent ALEKS attempt. There is no difference for additional attempts. These results replicate the results of the pilot study.

I analyzed the percentage of both groups that took the ALEKS a second or third time. These results are presented in Table 4.9.

Table 4.9

Percent of Students with Multiple Administrations of ALEKS

	Percent of Proctored Group	Percent of Unproctored Group
ALEK2	14.6	9.2
ALEK3	4.3	1.3

In both cases, the percentage of the proctored group that retook the ALEKS was significantly higher than the percentage of the unproctored group (ALEKS2: $\chi^2 = 27.43$, $p = .001$ ALEKS3: $\chi^2 = 59.983$, $p = .001$). These results are also the same as previously reported for the pilot study.

Data on the mean grades in the various math courses taken initially by students in the fall 2018 or spring 2019 semester are presented in Table 4.10. As shown in Table 4.10, there are significant differences in grades between the proctored and unproctored groups in College Algebra and Pre-Calculus, but non-significant differences in Pre-College Math and Calculus. These results replicate the pilot study except for the non-significant difference for Calculus. However, in the pilot study, Calculus was combined with the honors section of Calculus courses. My analysis does not combine Calculus with the honors section of Calculus courses. As shown in Table 4.10, the proctored group that completed Calculus obtained higher grades although this difference was not significant.

Table 4.10

Mean Course GPA from the Initial Math Course Taken for the Proctored and Unproctored Group

	Mean (Standard Deviation) for Proctored	Mean (Standard Deviation) for Unproctored	F	Significance	ηp2
Pre-College Math Courses	2.53 (1.19) (*n* = 279)	2.39 (1.34) (*n* = 454)	1.99	.159	.003
College Algebra	3.09 (.98) (*n* = 143)	2.31 (1.27) (*n* = 327)	24.27	.001	.085
Pre-Calculus	2.85 (1.02) (*n* = 110)	2.29 (1.29) (*n* = 374)	17.76	.001	.036
Calculus	2.71 (1.20) (*n* = 95)	2.52 (1.36) (*n* = 509)	1.57	.211	.003

F's and W's from Initial Math Course Taken

Additional analysis of the data suggests that the percentage of F and W course grades for students placed using a proctored placement test was less for all math courses except Pre-College Math when compared to the non-proctored placement test (College Algebra- 1.4% versus 10.7%, Pre-Calculus- 1.8% versus 11.2%, Calculus- 7.4% versus 11.6%).

Table 4.11

Percentage of F's and W's in the Initial Math Course for Proctored and Unproctored Groups

Course	Percentage of F's and W's Proctored	Percentage of F's and W's Unproctored
Pre-College Math	12.8	8.6
College Algebra	1.4	10.7
Pre-Calculus	1.8	11.2
Calculus	7.4	11.6

Current Research Study

The current study extends the research from the initial pilot study. This section describes the results of the analyses that address my research questions.

Research Question #1

My first research question asked whether there is a difference in math course performance in the second course taken between students who take the math placement test in an unproctored or proctored setting. To analyze the differences between groups, I

used ANOVA and hierarchical regression to understand if test administration modality is a predictor of final grades over and above the covariates.

Tables 4.12 through 4.14 compares the mean course grade for the second course taken between proctored and unproctored groups for courses into which students may place using the placement test. I analyzed the three possible combinations of course sequences separately: College Algebra following Pre-College Math; Pre-Calculus following College Algebra; and Calculus following Pre-Calculus. In each case, two analyses are presented. The first analysis compares the grades in the subsequent math course in the semester immediately following the first. The second analysis compares the grades if the subsequent math course was taken two semesters after the first. For example, if a student took Pre-College Math in fall 2018 and then took College Algebra in spring 2019, that student would be included in the first analysis. Students who took any of the second math courses in the summer were not included in the analysis.

Table 4.12 presents the mean grades in the second math course taken for Pre-College Math followed by College Algebra; Table 4.13 presents the mean grades in the second math course taken for College Algebra followed by Pre-Calculus; and table 4.14 presents the mean grades in the second math course taken for Pre-Calculus followed by Calculus.

Table 4.12

Students who Took Pre-College Math Followed by College Algebra

Semester College Algebra Taken	Mean Course Grade for Proctored	Mean Course Grade Unproctored	F	Significance	ηp2
Semester Following Pre-College Math	2.66 (1.09) (*n* = 66)	2.29 (1.05) (*n* = 84)	4.388	.038	.029
Two Semesters Following Pre-College Math	2.47 (.98) (*n* = 19)	2.12 (.96) (*n* = 17)	2.101	.103	.003

Table 4.13

Students who Took College Algebra Followed by Pre-Calculus

Semester Pre-Calculus Taken	Mean and Standard Deviation Course Grade for Proctored	Mean and Standard Deviation Course Grade Non-Proctored	F	Significance	ηp2
Semester Following College Algebra	2.63 (1.21) (*n* = 60)	2.13 (1.09) (*n* = 247)	12.598	.000	.032
Two Semesters Following College Algebra	2.55 (1.01) (*n* = 17)	1.93 (98) (*n* = 14)	6.785	.01	.044

Table 4.14

Students who Took Pre-Calculus Followed by Calculus

Semester for Calculus	Mean and (Standard Deviation) for Course Grade for Proctored	Mean and (Standard Deviation) for Course Grade Unproctored	F	Significance	ηp2
Semester Following Pre-Calculus	2.48 (1.28) (n = 45)	2.39 (1.31) (n = 126)	2.32	.078	.002

Note: The sample size was too small to analyze the data for two semesters (n = 15 for proctored and 17 for unproctored).

As shown above, students who took ALEKS in a proctored setting had higher average math grades in their next math course although some of these comparisons are not statistically significant. The largest difference is for Pre-Calculus for which proctored students have higher grades in both the first and second semester following College Algebra. The effect sizes in all cases are small to medium.

F's and W's from Second Math Course Taken

Table 4.15 presents analysis on the percentage of F's and W's from the second math course taken for students placed using a proctored placement test was less for all math courses when compared to the non-proctored placement test (College Algebra- 4.3% versus 11.7%, Pre-Calculus- 1.4% versus 9.8%, Calculus- 9.2% versus 18.1%).

Table 4.15

Percentage of F's and W's for Second Math Course Taken

Course	Percentage of F's and W's Proctored	Percentage of F's and W's Unproctored	Percentage of F's and W's for Entire Course
College Algebra	4.3	11.7	9.2
Pre-Calculus	1.4	9.8	7.9
Calculus	9.2	18.1	16.5

Multiple Regression Analyses

As a follow-up analysis to the results described above, hierarchical multiple regression analyses were conducted predicting the second math grade. I developed three regression models. Model 1 predicted the math grade given students' demographic variables that are typically used in this area of research and that were available in the dataset. These variables included gender, Pell Grant status, SAT Math, and High School GPA. Model 2 added the grade in the prior math course over and above the variables in Model 1. Finally, Model 3 added test administration modality over and above the variables in Models 1 and 2. Pearson correlations for all the predictor variables are also included in the results.

College Algebra following Pre-College Math

Table 4.16

Bivariate Correlations Predicting Grade in College Algebra

Predictor	Pearson Correlation	Significance
Gender (a)	-.095	.247
Pell Grant	-.203	.013
SAT MATH	.430	.001
High School GPA	.215	.009
Grade in Pre-College Math	.613	.000
Proctored (b)	.170	.038

(a) Female = 0; Male = 1
(b) Unproctored = 0; Proctored = 1

Table 4.17

Hierarchical Multiple Regression Predicting Grades in College Algebra following Pre-College Math

	Model 1			Model 2			Model 3		
	Beta	T	Significance	Beta	T	Significance	Beta	T	Significance
Gender	-.061	-.711	.478	-.011	-.150	.881	-.013	-.176	.860
Pell Grant	-.125	-1.506	.135	-.083	-1.144	.255	-.082	-1.124	.264
SAT Math	.491	5.821	.001	.282	3.443	.001	.274	3.317	.001
High School GPA	.321	3.688	.001	.200	2.542	.012	.197	2.490	.014
Grade in Pre-College Math				.470	5.785	.001	.466	5.715	.001
Proctored							.062	.856	.394

Note. R^2 = .273 for Model 1. R^2 = .444 for Model 2. R^2 = .445 for Model 3.

Table 4.18

Bivariate Correlations Predicting Grade in Pre-Calculus

Predictor	Pearson Correlation	Significance
Gender (a)	-.157	.106
Pell Grant	-.111	.087
SAT Math	.293	.001
High School GPA	.194	.003
Grade in College Algebra	.678	.001
Proctored (b)	.151	.020

(a) Female = 0; Male = 1
(b) Unproctored = 0; Proctored = 1

Table 4.19

Hierarchical Multiple Regression Predicting Grades in Pre-Calculus following College Algebra

	Model 1			Model 2			Model 3		
	Beta	T	Significance	Beta	T	Significance	Beta	T	Significance
Gender	-.175	-2.527	.012	-.075	-.981	.329	-.013	-.176	.862
Pell Grant	-.087	-1.284	.201	-.081	-1.120	.265	-.082	-1.124	.267
SAT Math	.315	4.553	.001	.104	1.302	.196	.274	3.317	.000
High School GPA	.205	3.012	.003	.110	1.444	.152	.197	2.490	.013
Grade in College Algebra				.623	8.114	.001	.456	5.715	.000
Proctored							.062	.856.863	.395

Note. R^2 = .158 for Model 1. R^2 = .486 for Model 2. R^2 = .487 for Model 3.

Calculus following Pre-Calculus

Table 4.20

Bivariate Correlations Predicting Grade in Calculus

Predictor	Pearson Correlation	Significance
Gender (a)	-.142	.014
Pell Grant	.001	.992
SAT Math	.163	.009
High School GPA	.258	.001
Grade in College Algebra	.652	.001
Proctored (b)	.086	.078

(a) Female = 0; Male = 1
(b) Unproctored = 0; Proctored = 1

Table 4.21

Hierarchical Multiple Regression Predicting Grades in Calculus following Pre-Calculus

	Model 1			Model 2			Model 3		
	Beta	T	Significance	Beta	T	Significance	Beta	T	Significance
Gender	-.101	-1.594	.112	-.156	-2.397	.018	-.150	-2.291	.023
Pell Grant	.043	.697	.487	.108	1.696	.092	.115	1.794	.075
SAT Math	.230	3.706	.001	.036	.560	.576	.035	.546	.586
High School GPA	.238	3.724	.001	.016	.235	.814	.016	.228	.820
Grade in Pre-Calculus				.618	9.462	.001	.635	9.546	.001
Proctored							-.080	-1.260	.210

Note. R^2 = .093 for Model 1. R^2 = .448 for Model 2. R^2 = .450 for Model 3.

Overall, the results of the correlations and multiple regressions are essentially the same for all three course sequences. At the univariate level, as expected, the strongest predictor of the grade in the second math course is the grade in the preceding math course. The SAT Math and High School GPA are also significant predictors by themselves. When the variables are combined in Model 3, in general, it is only the grade in the preceding math course that is significant. The modality of ALEKS administration is not significant in any of the multivariate analyses.

Research Question #2

The second research question asked whether there is a difference in the number of semesters in which students persist between students who take the math placement test in an unproctored or proctored setting. To analyze the research question, I used two different approaches to understand student persistence. The first is the number of consecutive semesters in which a student enrolled at the same institution. Table 4.22 shows the percentage of students who were retained all semesters without stopping out. The second is the number of semesters completed by each student, which includes students who did not complete consecutive semesters of coursework. Table 4.23 shows the number of students in both proctored and unproctored groups who took classes in a given semester. I used undergraduate GPA for each semester as an indicator for a student attending in a given semester. Both methods showed a higher percentage of students retained in the proctored group compared to the unproctored group, however, the differences between proctored and unproctored percentage rates were not statistically significant.

Table 4.22

Percentage of Students Retained by Using Students who have GPAs in All Semesters

Proctored	75.3%
Unproctored	72.6%

The difference between these two percentages was not significant ($\chi^2 = 2.38$, $p = .076$).

Table 4.23

Persistence of Students Per Semester

Semester	Number Proctored	Number Unproctored
Fall, 2018	537	1667
Spring, 2019	521	1604
Fall, 2019	489	1482
Spring, 2020	468	1412
Fall, 2020	458	1355
Spring, 2021	437	1308
Fall, 2021	432	1284
Percent Retained	80.4%	77.0%

As above, the difference between the two percentages was not significant ($\chi^2 = 2.98$, $p = .069$)

Additional Analysis

In addition to the analysis to answer the primary research questions, the data provided information to answer peripheral questions not part of the primary research study. A summary of the results is presented below.

Cumulative GPA

Additional analysis shown in Table 4.24 presents the means for cumulative GPA across all seven semesters included in the data between groups. The proctored group continues to have a higher cumulative GPA for each subsequent semester.

Table 4.24

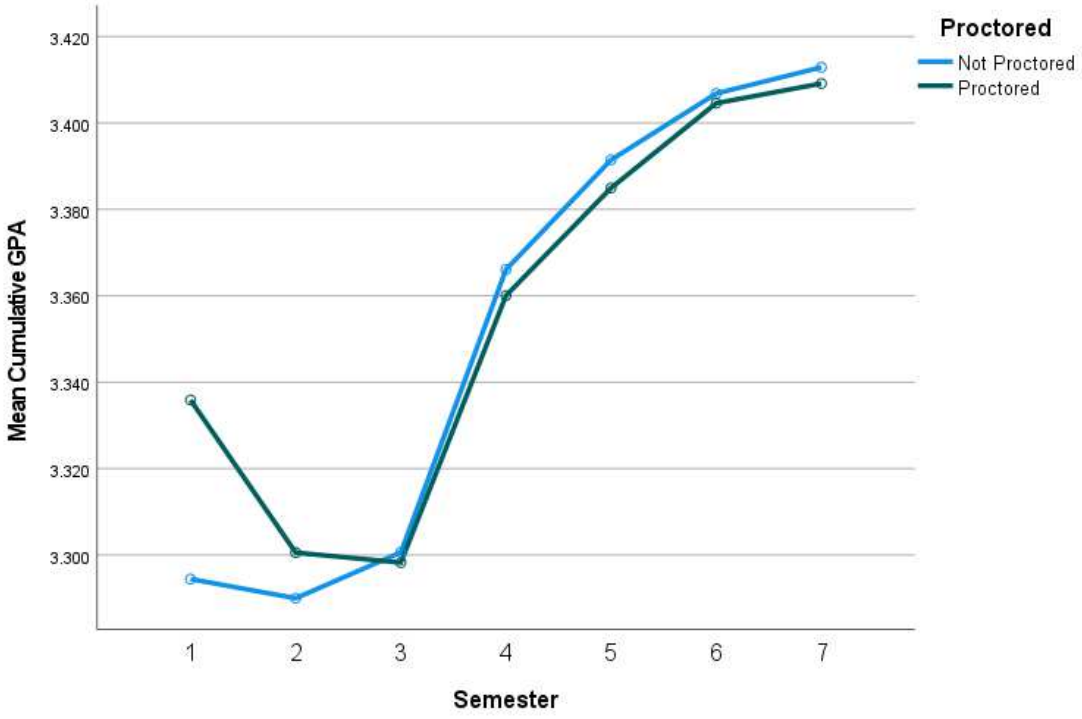
Cumulative GPA by Semester

Semester	Proctored	Unproctored
Fall, 2018	3.31	2.96
Spring, 2019	3.21	2.99
Fall, 2019	3.12	3.01
Spring, 2020	3.21	3.15
Fall, 2020	3.24	3.18
Spring, 2021	3.28	3.20
Fall, 2021	3.27	3.20

A graph of the data is presented in Figure 4.1.

Figure 4.1

Graph of Cumulative GPA by Semester



The repeated measures ANOVA indicated that there was a significant main effect for semester F = 183.352, p = .001, ηp^2 = .046) and a significant interaction F = 5.44, p = .005, ηp^2 = .001. The main effect for group is not significant. As shown in Figure 4.1, the proctored group has a significantly higher GPA in the first and second semester but no difference from that point on. It should be noted that the GPAs are computed only for subjects who were retained all seven semesters. A semester-by semester analysis was also conducted which produced the same result.

Analysis of ALEKS

ALEKS PPL is the assessment tool used to determine student's course placement. Table 4.25 shows the mean ALEKS scores for the four courses included in the data set. The table also includes the mean ALEKS scores for students who were enrolled in the honors section of Calculus. The means were computed on the student's highest ALEKS score. There are potential limitations in this analysis with restriction of range given that the range of data does not include the full range of possible ALEKS scores. As expected, the mean ALEKS score for each math course increases with the level of math course taken.

Table 4.25

Mean ALEKS Scores by Course

	Mean	Standard Deviation	Range
Pre-College Math	23.75	12.265	3 – 36
College Algebra	55.02	9.054	46 – 78
Pre-Calculus	66.82	9.514	46 – 85
Calculus	75.75	9.342	60 – 97
Honors Calculus	83.36	5.914	76 – 96

Correlations of Course Grades with ALEKS

ALEKS scores were correlated with course grades for each of the courses in the dataset. Tables 4.26 and 4.27 show the correlations between first ALEKS score and final grades between proctored and unproctored cohorts. For this analysis, the STEM track version of Pre-College Math and the non-STEM track version of Pre-College Math were separated since the results were somewhat different. These correlations were computed

on two different versions of ALEKS that were in the dataset. The first way was to use the highest ALEKS score that a student obtained if they took the screening test more than once. The second set of correlations used the score form the ALEKS that was taken first.

Table 4.26

Correlations with the Highest ALEKS Score

	Total Cohort	Proctored	Unproctored
Pre-College Math (Non-STEM Track)	.250*	.481**	.213
Pre-College Math (STEM Track)	.493**	.607**	.487**
College Algebra	-.017	.216	.027
Pre-Calculus	-.006	-.066	.060
Calculus	-.071	-.142	-.052

Table 4.27

Correlations with the First ALEKS Score

	Total Cohort	Proctored	Unproctored
Pre-College Math (Non-STEM Track)	.224*	.425**	.210
Pre-College Math (STEM Track)	.457**	.583**	.444**
College Algebra	.094	.142	.130
Pre-Calculus	.177**	.350**	.203**
Calculus	.173**	.436**	.171**

As shown in Tables 4.26 and 4.27 there is a difference between the highest ALEKS score and the first ALEKS score with correlations with the first ALEKS score being higher and more typically significant. Table 4.27 shows the correlation between first ALEKS score and final grades in the course taken. For each course, except College Algebra, there is a significant correlation between first ALEKS score and final grades in course taken. In addition, between proctored and unproctored groups, the first ALEKS score from a proctored math placement test is more highly correlated to final grades in four of five math courses compared to scores from unproctored math placement test results.

Change of Major

Table 4.28 presents the number of students from the study sample who changed their major from the fall 2018 to the fall 2021 semester. When analyzed as a function of proctoring, the change was not significant.

Table 4.28

Number of Students within the Study Sample that Changed their Major from Fall 2018 to Fall 2021

	No	Percent of Group Total	Yes	Percent of Group Total	Total
Proctored	160	29.8	377	70.2	537
Unproctored	467	28.0	1200	72.0	1667
Total Study Sample	627	28.4	1577	71.6	2204

Table 4.29 presents the number of students from the total admissions cohort that changed their major from the fall 2018 to the fall 2021 semester. The percent of students that change their majors from the total admissions cohort is 64.5%. This is more than six percentage points lower than students included within the study.

Table 4.29

Number of Students within the Total Admissions Cohort that Changed their Major from Fall 2018 to Fall 2021

	No	Percent of Group Total
No	1795	35.5
Yes	3255	64.5
Total Admissions Cohort	5050	100

CHAPTER 5

DISCUSSION

My study examined if there are differences in math course performance for second math courses taken and college student enrollment persistence between students who complete a proctored or unproctored math placement test. Prior research on the differences of proctored and unproctored assessments in educational settings are inconclusive as some studies suggest that test administration modality results in lower academic performance, such as test scores, while other studies suggest that there is no difference on academic performance because of test administration modality. In addition, there is limited literature on whether there are differences in math course performance and college student enrollment persistence between students who completed a proctored or unproctored placement test. My study analyzed data from an institution that assigned students to take a math placement test in a proctored or unproctored setting to expand literature on this topic.

The data analyzed for my study were collected as part of a pilot study in which the institution analyzed whether there was a difference in placement level and academic performance in the initial math course taken between students who took a math placement test in a proctored and unproctored setting. Findings from the pilot study in 2018 suggest that students tend to place about one course level lower when placed using a proctored math placement tests compared to an unproctored group. In addition, students tend to perform better as measured by final grades in their initial math course when placed using a proctored math placement test. It is logical to believe that success in

students' initial course will lead to future success in subsequent courses. As such, the current study tests this assumption by investigating the success for each student in the proctored and unproctored groups in the second math course taken.

This chapter describes the findings of the current study. The chapter is organized by research question, providing a summary of findings as well as implications for practice. Included are limitations of my study and recommendations for future research.

Summary of Findings

Summary of the findings for the first research question. My first research question asked whether there is a difference in math course performance in the second math course taken between students who take the math placement assessment in an unproctored or proctored setting. Prior studies on proctoring and academic outcomes provided mixed results. Some suggest that students who take assessments in an unproctored environment earn higher grades on classroom assessments (Alessio et al., 2017; Daffin & Jones, 2018; Goedl & Malla, 2020; Prince et al., 2009). Other studies suggest that there is no difference in grades on assessments taken in an unproctored or proctored setting (Beck, 2014; Brallier & Palm, 2015; Ladyshewsky, 2015; Rios & Liu, 2017; Yates & Beaudrie, 2009). An initial pilot study conducted at a large, urban, Mid-Atlantic research institution suggested that there is a difference in placement level and final grades in the first math course taken between students who take a math placement assessment in an unproctored or proctored setting. I hypothesized that the difference in math course performance in the second math course taken would continue following the first.

The intent of my first research question was to extend the findings gleaned from the initial pilot study. That is, the objective was to understand if a difference between math course performance in the first math course taken between students who take the math placement assessment in an unproctored or proctored setting continues beyond the first math course. Overall, my findings suggest that a difference in math course performance between groups continues into the second math course. However, while the proctored group had higher math course performance than the unproctored group in the second math course, test administration modality was not a statistically significant predictor over and above other factors which were identified in the study as potential covariates. In particular, final grade in the previous math course was the most statistically significant predictor of performance for each of the courses available in the math course sequence.

The analyses presented in Chapter 4 show that not only is there a difference in performance as indicated by final grades in the course but lower rates of students who earn F's or W's in the proctored group compared to the unproctored group. Additionally, this was true for the initial math course taken and for the second math course taken. The fact that more students in the unproctored group earn F's or W's suggests that the practice of proctoring during placement tests is not just an issue about higher or lower passing grades but about whether students will pass altogether and as such is a practice that institutions should consider continuing.

Summary of the findings for the second research question. The second research question asked whether there is a difference in the number of semesters in which students

persist between students who take the math placement test in an unproctored or proctored setting. The pilot study suggests that students who take the math placement assessment in a proctored setting earn higher grades in their initial courses. I hypothesized that the success from the first course would continue into the second math course taken, which could be a contributing factor along with other grade performance for student persistence (Tinto, 1975). The intent of Research Question #2 was to understand broader, longitudinal differences between students who take the math placement test in an unproctored or proctored setting. Overall, findings suggest that there is a difference in the number of consecutive and non-consecutive semesters completed between students who take the math placement test in a proctored and unproctored setting. However, the difference in student retention between groups is not statistically significant.

Discussion of Findings

Second Math Course Taken

Findings from the initial pilot study suggest that students place approximately one course level lower and have higher final grades in their initial courses if they complete the math placement test in a proctored setting. By extending the analysis to the second math course taken, my study provides more information about the differences between groups. Differences in academic performance between groups continue into the second math course taken. While test administration modality is not a statistically significant predictor of final course grades in the second math course taken, final grades in the initial math course taken was significant over and above students' gender, socioeconomic status, and HS GPA. Similarly, the percentage of F's and W's for the initial math course

taken and second math course taken differs between groups with the percentage of proctored students with F's and W's less than the percentage of students with F's and W's for unproctored students. This raises the question of whether test administration modality has an indirect effect on second math course taken. That is, students' final course grade in the second math course is largely predicted by their final course grade in the first math course, which was impacted by whether their test was taken in a proctored or unproctored setting.

Analysis in Chapter 4 suggests that the differences in cumulative GPA is greater for the first couple of semesters between students who take proctored or unproctored math placement test, but the difference diminishes quickly over time. This may suggest that proctoring as a practice is not worth the associated costs; however, the rates of F's and W's in the initial and second math course taken would suggest otherwise. To decrease the amount of F's and W's in math courses within the first couple of semesters, institutions should consider the practice of proctoring math placement tests.

Several factors contribute to student success, but data from the pilot and my current study could serve as a reminder to develop a placement process that does not over-place students. Proctored students, who were typically placed one course level lower than their unproctored peers in the study, were more successful (and have less percentages of F's and W's) in their initial and second math course. Placing them in higher courses initially could result in lower academic performance and test administration modality is an important component of placement tests and course placement. That said, placing students into courses requires institutions to balance

priorities. My study suggests that some students are being over-placed at the study site, which is resulting in lower academic performance.

Persistence

Persistence is a complex phenomenon that is determined by a wide variety of factors. My current study suggests that while there is a difference in persistence between groups, the difference is not statistically significant. The fact that there are not significant differences in persistence between groups could be due to a variety of factors. For example, the current study used GPA as an indicator of attendance for each semester. It is plausible that while students were less successful in their second math course if they took the math placement test in the unproctored group, they still performed well-enough to continue in their studies at the study site. Moreover, persistence continues for students when studies suggest that taking developmental courses has been associated with increased time to degree and decreased persistence (Burdman, 2012). One implication from proctoring placement tests was that more students were placed into developmental courses (Martin et al., 2019), which would presumably mean that students would be less likely to persist if placed into lower levels of math. Yet, my current study does not find significant differences in persistence between groups. More research is needed to understand why that is the case.

Appropriate Course Placement

To assess students' academic proficiencies and to place them into the course level deemed appropriate for the student by the institution, including developmental courses,

institutions establish and apply course placement policies using student data or placement test results (Abraham, 1992; Barnett & Reddy, 2017; Fields & Parsad, 2012; Frisbie, 1982). The current study demonstrates how dependent the course placement is based upon the individual institution and placement process. At the study site, students may be automatically placed based upon their student data, may be required to take a placement test, or given the option, may retake the assessment. In addition to differences in their institutional characteristics, curricular pathways, and student body, other institutions have additional nuances to their placement process that make it difficult to determine appropriate course placement and reinforce the idea that course placement is an institutional-level decision. What works at one institution may not necessarily translate to another or produce the same results.

Cost Benefit Analysis

The impetus for many institutions to offer online placement assessments, unproctored was the accessibility of technology (Foster, 2013). Institutions moved placement tests online to leverage logistical and financial benefits. These data suggest that proctoring placement tests may be worth the costs to improve student success by lowering the number of F's and W's in the initial and second math course students take.

Limitations

There are several limitations of the current study including challenges replicating the pilot study, narrow scope of analysis, limited variables, generalizability across disciplines, and interpreting results.

Replicating the Pilot Study

First, as an extension of the pilot study, the current study used data from the fall 2018 first-year cohort and first replicated results from the pilot study. Since the full research team is no longer accessible and the unpublished manuscript does not provide adequate methodological details which limited its replicability, there are subtle differences between the findings from the pilot study and the current study when attempting to replicate the research. Some of the differences during replication are due to including incoming fall 2018 students who took an initial math course in the spring. The decision was made to include these students to increase participants. In addition, the unpublished manuscript does not provide necessary information on decisions made during the pilot study. However, overall findings still affirm the pilot study findings in that students tend to place one course level lower if they take a proctored placement test and students tend to perform better as measured by final grades in the course if they were placed by a proctored placement test.

Narrow Scope of Analysis

Although my focus for this study was on courses taken within the institution's identified math course sequence, my current study would provide a more comprehensive understanding of my research questions if it included all possible second math course options for students. This would require that my data include general education courses and possibly statistics courses as these would satisfy some degree programs and therefore be the second math course taken for some students. Statistics courses, for example, are a requirement for most students in the business school at the study site. My data did not

include this information, however, so the study was limited to courses taken along the math course sequence and students in these programs a not included in my sample.

Study Variables

In addition, it is important to understand that many factors are involved in academic performance and may predict student success. A limitation of my current study is accounting for the multitude of factors (e.g., faculty interaction, institutional effectiveness, individual characteristics, etc.) that may impact student performance in an initial math course as well as subsequent courses (Tinto, 1975). My current study only includes a fraction of the factors, focusing on information readily available from the institution, such as students' demographic characteristics and prior academic performance. Including additional factors would provide a broader understanding of success in initial and second math course taken as well as student persistence. Moreover, my study used math course performance to understand the differences of test administration modality during placement tests on math course performance beyond the initial math course. However, the more time that passes between the placement test and the completion of coursework, the more likely that other factors impact students' success. To control for the effects of these other variables, the study included covariates such as demographic characteristics and math proficiency, but many more factors should be included to develop a more complete understanding of student success in relation to the research questions. This should also be a consideration when interpreting results.

Generalizability across Disciplines

Another limitation within my current study is how the differences of proctored placement assessments may arise within particular academic schools, colleges, departments, or majors. It is possible that the impact of proctored math placement tests is more significant for programs that require higher levels of math. The 2018 pilot study suggests, for example, that students in programs that require higher levels of math (pre-calculus or higher) were more likely to retake the placement assessment in a proctored setting (Martin et al., 2019). It may be beneficial to further the study of test administration modality on placement tests due to major and math program requirements to understand the differences of proctored placement tests in student performance and persistence within specific groups.

ALEKS

As part of my secondary analysis, I conducted an analysis of ALEKS scores and their correlations with final course grades. Specifically, I analyzed the correlations between each ALEKS attempt for both scores from attempts in the order they were taken and highest ALEKS score. The findings suggest that the highest ALEKS score is correlated to grades in Pre-College Math only and the scores from the first ALEKS attempt is correlated to grades in all math courses included in the study except College Algebra. Ideally, ALEKS scores would correlate to grades in all available courses. Differences in correlation between ALEKS scores and final course grades raises the question of whether there is consistency in what ALEKS measures and what is taught in the courses included in the study. In addition, the differences in correlation between each

ALEKS attempt and highest attempt is an example of the results from the study may not be generalizable to other institutions as other study sites may not permit the highest ALEKS score to be used for course placement or may permit a different number of attempts.

Interpreting Results

The primary purpose of my current study was to determine if there is a difference in the academic success and persistence between students who completed a proctored or unproctored placement test. The secondary purpose of my study was to provide information that may help institutions make decisions about whether to proctor placement tests. The results of the study, however, should be interpreted with caution. There are many decisions institutions make regarding the placement process, including whether a placement test is the most reliable and valid tool to assess students' academic readiness for college coursework. My study should contribute to broader discussions about other assessment methods and placement policies that may yield better success rates for students.

My current research is specifically relevant for institutions that choose to use a math placement test to determine students' course placement. Reproducing the same results of the research may vary among institutions based upon student body, institutional characteristics, and policy. It will also vary based upon variation in the placement process for the participating institution. In my current study, the institution automatically placed students into courses based on SAT/ACT scores and gave them the option to take an assessment to improve their placement. Moreover, students were given the option for two

additional attempts. The differences in the placement process may result in differences in the outcomes.

Directions of Future Research

There are opportunities to extend my findings and address the limitations of the current study. As noted, including data from students who completed general education and statistics courses would provide a more comprehensive understanding of the research questions by including all possible second math course options for students. All degree programs at the institution do not require students to complete courses along the math course sequence. Students enrolled in these degree programs whose second course is outside the math course sequence are not captured in the current study, providing an opportunity for future research. Another limitation that provides opportunities for future research is that placement processes vary widely by institution. Replicating the same study at different institutions with different placement policies, procedures, and assessments, would further increase the external validity of my study. There is also opportunity to complete qualitative research that includes data from students and test administrators that would expand knowledge on this topic.

Types of Proctoring

Data collected from my study came from a pilot study in which incoming first year students were assigned to take the math placement test in either a proctored or unproctored setting. The pilot study used a remote, online solution provided by a vendor in which the student initiated the test session with a proctor who authenticated their identity and secured their environment. Once the test session started, the session was

recorded and reviewed later. Other options include a fully automated monitoring experience in which the student never interacts with a live, human proctor. Alternatives include interaction and monitoring by a live, human proctor who can intervene in real-time to address any issues for standardization and test security. In addition to the questions addressed in my study, there are other questions that institutions should consider when deciding whether to continue the practice of proctored placement tests, such as what type of service (i.e., remote proctoring versus in-person proctoring, proctoring through computer applications versus proctoring with a live human) to use to proctor their own assessments. Such a wide range of options leads to opportunities to explore whether the findings from the pilot and my current study apply when conducted using other proctoring methods.

Recommendations for Higher Education

Institutions may consider unproctored math placement tests to overcome logistical and financial challenges. Findings from the pilot study caution institutions to consider continuing the practice of proctoring math placement tests as students tend to perform better academically in their initial math course taken when they are placed using a proctored math placement test. However, institutions that make the decision to proctor placement tests need to understand if test administration modality results in positive differences in student success beyond students' initial math course. Reviewing such information along with other data would potentially strengthen the case for proctored placement assessments or demonstrate that the differences of test administration modality during placement tests diminishes over time, reinforcing that financial and administrative

efficiencies (i.e., not proctoring placement tests) can be implemented with little long-term impact on student performance.

My current study examines course grades from the second math course taken and persistence from a 2018 incoming first year cohort in which students were randomly assigned to a proctoring group when completing a placement test. At the time of analysis, my study sample had completed two and a half academic years, which provided information to better understand the performance of these students in math courses beyond their initial math course taken and their persistence over time. My current study suggests that the differences between the academic performance of proctored and unproctored students continues through to the second math course taken, which is evident in the mean final course GPA in the initial and second math course taken and percentages of F's and W's between students in proctored and unproctored groups. Students tend to perform better in their initial math course if placed using a proctored math placement test and the grades from the initial math course tend to predict success in second math course taken.

Given the findings, institutions with a similar math placement process as the study site should consider keeping the practice of proctored placement tests as it could lead to higher rates of student success in their initial and second math courses as well as greater rates of retention. This is particularly generalizable to institutions that use the ALEKS assessment online. Other institutions should consider applying the research to their own placement process. After applying the research, it is possible that regardless of the tool used that institutions may determine that proctoring placement tests is worth the

associated logistical and financial costs. Such a decision may be in the best interest of students and their success. That said, my current research focuses on institutions that use placement tests to determine course placement. Such research should not detract from broader conversations regarding the best methods for placing students, whether that be through automatic placement using student data, tests, or other means. My current research supports proctoring for institutions similar to the study site that offer a placement test for course placement.

Conclusion

Students enroll in college with a wide range of academic proficiencies. Placement testing is one method by which institutions assess students' readiness for college-level coursework. As electronic methods became available to administer assessments, institutions moved placement tests online to leverage both financial and logistical benefits. However, in addition to transitioning assessment online some institutions also transitioned the administration of placement tests to an unproctored setting. Changing the test administration modality of an assessment without supporting data raises concerns about the reliability and validity of the test results. Literature on classroom exams found mixed results about the differences of unproctored and proctored tests and course grades. In 2018, a pilot study administered a math placement test to an incoming first-year cohort in which students were assigned to either an unproctored or proctored condition. Findings from the pilot study suggest that students who take the math placement test proctored place approximately one course level lower and achieve overall higher grades than students who take the math placement test unproctored.

Based on the results presented in Chapter 4, the difference in math course grades between students who take the math placement test in an unproctored or proctored setting continues through the second math course taken, which is evident through mean final course GPA in the initial and second math course as well as the percentage of students with F's and W's between proctored and unproctored groups. However, the analyses suggests that when accounting for other factors that predict course grades, test administration modality is not a statistically significant predictor. Rather, of the covariates included, final course grade from the initial math course taken is the most statically significant predictor of success amongst all math courses studied. In addition, findings from my current study show that the retention rates for students who take the math placement test in a proctored setting are a few percentage points higher than for students who take the math placement test in an unproctored setting.

Such findings are not surprising. It is reasonable to believe that students who achieve high grades in their initial math course will have high grades in the second math course. Because initial math course grades are good predictors of grades in the second math course taken, it is important that students succeed in their initial math course. As suggested by the pilot study, students who take a proctored math placement test are more likely to succeed in their initial math course. My current study demonstrates the importance of placing students into initial math courses in which they can succeed as it sets them up for success in future courses.

REFERENCES

Abraham, A. A. (1992). *College remedial studies: Institutional practices in Southern Regional Education Board states*. Atlanta, GA: Southern Regional Education Board. Retrieved June 17, 2021, from https://files.eric.ed.gov/fulltext/ED345617.pdf

ALEKS PPL Provides Developmental Support, Places Students More Accurately, and Improves Student Success. (n.d.) University of Kentucky. Retrieved November 20, 2021, from https://s3.amazonaws.com/ecommerce-prod.mheducation.com/unitas/highered/platforms/aleks/univ-of-kentucky-case-study.pdf

ALEKS PPL Significantly Improves Students' Placement and Performance in College-Level Math Courses. (n.d.) William Rainey Harper College. Retrieved November 20, 2021, from https://s3.amazonaws.com/ecommerce-prod.mheducation.com/unitas/highered/platforms/aleks/aleks-ppl-case-study-harper-college.pdf

Alessio, H. M., Malay, N., Maurer, K., Bailer, A. J., & Rubin, B. (2017). Examining the effect of proctoring on online test scores. *Online Learning, 21*(1), 146-161. http://dx.doi.org/10.24059/olj.v21i1.885

American Educational Research Association., American Psychological Association., National Council on Measurement in Education, and Joint Committee on Standards for Educational and Psychological Testing (2014). *Standards for educational and psychological testing*. Washington, DC: American Educational Research Association.

Association of Testing Publishers & National College Testing Association. (2015). *Proctoring best practices.* CreateSpace Independent Publishing Platform.

Barnett, E. A., & Reddy, V. (2017). College placement strategies: Evolving considerations and practices (A CAPR Working Paper). New York, NY: Community College Research Center. Retrieved June 14, 2021, from https://files.eric.ed.gov/fulltext/ED583509.pdf

Beaty, J. C., Nye, C. D., Borneman, M. J., Kantrowitz, T. M., Drasgow, F., & Grauer, E. (2011). Proctored versus unproctored internet tests: Are unproctored noncognitive tests as predictive of job performance? *International Journal of Selection and Assessment, 19*(1), 1-10. https://doi.org/10.1111/j.1468-2389.2011.00529.x

Beck, V. (2014). Testing a model to predict online cheating: Much ado about nothing. *Active Learning in Higher Education, 15*(1), 65-75. https://doi.org/10.1177/1469787413514646

Bettinger, E. P., Boatman, A., & Long, B. T. (2013). Student supports: Developmental education and other academic programs. *The Future of Children*, *23*(1), 93-115. Retrieved June 14, 2021, from http://www.jstor.org/stable/23409490

Bettinger, E. P., & Long, B. T. (2009). Addressing the needs of underprepared students in higher education: Does college remediation work? *Journal of Human Resources, 44*(3), 736–771. https://doi.org/10.3368/jhr.44.3.736

Bickerstaff, S., Kopko, E., Lewy, E., Raufman, J. & Zachry Rutschow, E. (2021). Implementing and Scaling Multiple Measures Assessment in Context of COVID-19 (CARP Research Brief). New York, NY: Community College Research Center. Retrieved June 14, 2021, from https://files.eric.ed.gov/fulltext/ED610605.pdf

Boatman, A., & Long, B. T. (2018). Does remediation work for all students?: How the effects of postsecondary remedial and developmental courses vary by level of academic preparation. *Educational Evaluation and Policy Analysis, 40*(1), 29-58. https://doi.org/10.3102/0162373717715708

Brallier, S., & Palm, L. (2015). Proctored and unproctored test performance. *International Journal of Teaching and Learning in Higher Education, 27(*2), 221-226. https://files.eric.ed.gov/fulltext/EJ1082856.pdf

Burdman, P. (2012). *Where to begin? The evolving role of placement exams for students starting college*. Jobs for the Future. https://files.eric.ed.gov/fulltext/ED537265.pdf

Chen, X. (2016). Remedial coursetaking at U.S. public 2- and 4-year institutions: Scope, experiences, and outcomes (NCES 2016-405). Washington, DC: National Center for Education Statistics, U.S. Department of Education. Retrieved July 30, 2021, from https://nces.ed.gov/pubs2016/2016405.pdf

Daffin, Jr., L.W., & Jones, A.A. (2018). Comparing student performance on proctored and nonproctored exams in online psychology courses. *Online Learning, 22*(1), 131-145. https://doi:10.24059/olj.v22i1.1079

Davies, S. A., & Wadlington, P. L. (2006, May). Factor and parameter invariance of a five factor personality test across proctored/unproctored computerized administration. Paper presented at the 21st Annual Conference of the Society for Industrial and Organizational Psychology, Dallas, TX. Retrieved June 14, 2021 from https://www.researchgate.net/profile/Patrick-Wadlington-2/publication/255655545_Factor_Parameter_Invariance_of_a_Five_Factor_Personality_Test_across_ProctoredUnproctored_Computerized_Administration/links/53fca8c10cf22f21c2f3f3c0/Factor-Parameter-Invariance-of-a-Five-Factor-Personality-Test-across-Proctored-Unproctored-Computerized-Administration.pdf

Dyer, J. M., Pettyjohn, H. C., & Saladin, S. (2020). Academic Dishonesty and Testing: How Student Beliefs and Test Settings Impact Decisions to Cheat. *Journal of the National College Testing Association, 4*(1), 1-30. https://www.ncta-testing.org/assets/docs/JNCTA/2020%20-%20JNCTA%20-%20Academic%20Dishonesty%20and%20Testing.pdf

Fields, R., & Parsad, B. (2012). *Tests and cut scores used for student placement in postsecondary education: Fall 2011.* Washington, DC: National Assessment Governing Board.

Foster, D. (2009). *Effective online methods for preventing and detecting cheating on internet tests*. European Congress of Psychology, Oslo.

Foster, D. (2013). Security issues in technology-based testing. In Wollack, J.A. & Fremer, J. J. (Eds.), *Handbook of test security* (pp. 39-83). Routledge.

Frisbie, D. A. (1982). Methods of evaluating course placement systems. *Educational Evaluation and Policy Analysis*, *4*(2), 133-140. https://www.jstor.org/stable/1164008

Ganter, S. L., & Haver, W. E. (Eds.). (2011). *Partner discipline recommendations for introductory college mathematics and the implications for college algebra*. Mathematical Association of America. Retrieved June 14, 2021, from https://www.maa.org/sites/default/files/pdf/CUPM/crafty/introreport.pdf

Goedl, P. A., & Malla, G. B. (2020). A study of grade equivalency between proctored and unproctored exams in distance education. *American Journal of Distance Education*, 1-10. https://doi.org/10.1080/08923647.2020.1796376

Hagedorn, L. (2012). How to define retention: A new look at an old problem. In Siedman (Ed.), *College student retention: A formula for success* (pp. 81-100). Rowman & Littlefield Publishers, Inc.

Hample, R. (2018, November 17). [Longitudinal Trends in Placement Policies]. Unpublished raw data.

Haladyna, T. (2006). Perils of standardized achievement testing. *Educational Horizons,* 30-43. Retrieved October 14, 2021, from https://www.jstor.org/stable/42925964

Haladyna, T., Nolen, S., & Hass, N. (1991). Raising standardized achievement test scores and the origins of test score pollution. *Educational Researcher, 20*(5), 2-7. https://doi-org.libproxy.temple.edu/10.3102/0013189X020005002

Harmon, O. R., & Lambrinos, J. (2008). Are online exams an invitation to cheat? *The Journal of Economic Education*, *39*(2), 116-125. https://doi.org/10.3200/JECE.39.2.116-125

Hossler, D., & Bontrager, B. (Eds.). (2015). *Handbook of strategic enrollment management*. John Wiley & Sons.

Hughes, K. L., & Scott-Clayton, J. (2011). Assessing developmental assessment in community colleges. *Community College Review*, *39*(4), 327-351. https://doi.org/10.1177/0091552111426898

Iowa Central Community College. (n.d.) ALEKS PPL Case Study. Retrieved November 20, 2021, from https://s3.amazonaws.com/ecommerce-prod.mheducation.com/unitas/highered/platforms/aleks/aleks-ppl-case-study-iowa-central.pdf

Jaggars, S. S., Hodara, M., Stacey, G. W. (2013). Designing meaningful developmental reform. New York, NY: Community College Research Center, Columbia University. Retrieved June 14, 2021, from https://files.eric.ed.gov/fulltext/ED539912.pdf

Ladyshewsky, R. K. (2015). Post-graduate student performance in 'supervised in-class' vs. 'unsupervised online' multiple choice tests: implications for cheating and test security. *Assessment & Evaluation in Higher Education, 40*(7), 883-897. https://doi.org/10.1080/02602938.2014.956683

Lubienski, S. T. (2001). A second look at mathematics achievement gaps: Intersections of race, class, and gender in NAEP Data. Paper presented at the American Educational Research Association, Seattle, WA. Retrieved June 14, 2021, from http://files.eric.ed.gov/fulltext/ED454246.pdf

Maher J., Markey J., & Ebert-May D. (2013). The other half of the story: Effect size analysis in quantitative research. CBE Life Sci Educ, 12(3), 345-51.

Martin, J., Hample, R., Calzaferri, G., & Starr, J. (2019). *Examining the effects of remote proctoring on math course placement and success: A randomized control trial* [Unpublished manuscript].

Mertens, D. M. (2020). Research and evaluation in education and psychology (5th ed.). Sage.

Morante, E. A. (1987). A primer on placement testing. *New Directions for Community Colleges, 1987*(59), 55-63. https://doi.org/10.1002/cc.36819875909

Porter, A. C., & Polikoff, M. S. (2012). Measuring Academic Readiness for College. *Educational Policy, 26*(3), 394-417. https://doi.org/10.1177/0895904811400410

Prince, D. J., Fulton, R. A., & Garsombke, T. W. (2009). Comparisons of proctored versus non-proctored testing strategies in graduate distance education curriculum. *Journal of College Teaching & Learning (TLC), 6*(7). https://doi.org/10.19030/tlc.v6i7.1125

Redden, E. (2021, January 20). New research brief looks at how pandemic has upset the status quo for placement tests. *InsideHigherEd.* https://www.insidehighered.com/news/2021/01/20/new-research-brief-looks-how-pandemic-has-upset-status-quo-placement-tests

Rios, J. A., & Liu, O. L. (2017). Online proctored versus unproctored low-stakes internet test administration: Is there differential test-taking behavior and performance? *American Journal of Distance Education*, *31*(4), 226-241. https://doi.org/10.1080/08923647.2017.1258628

Rodríguez, O., Bowden, B., Belfield, C., & Scott-Clayton, J. (2015). Calculating the costs of remedial placement testing. CCRC Analytics. Community College Research Center, Teachers College, Columbia University. Retrieved June 14, 2021, from https://files.eric.ed.gov/fulltext/ED562055.pdf

Rodríguez, O., Bowden, A. B., Scott-Clayton, J. E., & Belfield, C. (2014). Remedial placement testing in community colleges: What resources are required, and what does it cost? Retrieved June 14, 2021, from https://doi.org/10.7916/D8TX3D1B

Saxe, K. & Braddy, L. (2015). *A common vision for undergraduate mathematical sciences programs in 2025.* Mathematical Association of America. Retrieved June 14, 2021, from https://www.maa.org/sites/default/files/pdf/CommonVisionFinal.pdf

Scott-Clayton, J. (2012). *Do high-stakes placement exams predict college success?* (CCRC Working Paper No. 41). Community College Research Center, Teachers College, Columbia University. Retrieved June 14, 2021, from https://files.eric.ed.gov/fulltext/ED529866.pdf

Scott-Clayton, J., Crosta, P. M., & Belfield, C. R. (2014). Improving the targeting of treatment: Evidence from college remediation. *Educational Evaluation and Policy Analysis, 36*(3), 371–393. https://doi.org/10.3102/0162373713517935

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research,* 3(7), 749-752. Retrieved October 5, 2021 from https://d1wqtxts1xzle7.cloudfront.net/58765080/Pros_and_cons_of_sampling-with-cover-page-v2.pdf?Expires=1633449216&Signature=gr8YF0Fs~-H-PB0es6CTFiGWJM~8NLkATupOvG4~XHsgfAB7nE9Prjhx9POd~nZKfN-eOjxPjTjaMe9dsSvJgok8~MDRrQLWDYaZrHOHnauKi23Q7Bs~GOshm0WzhA5Ucv8KyiALvsJmbtS9jdghSkyEKM~DU3mKGG2iaqRu~9Wqn-M8Zz25H2C7yFh0jf0-jDW1TVAhKwihjIclgLC43rxAA5t3O1o2ilFR3aKdowW9JV1lzLDARTje33634De~aH~mh1rmZ06qnbjGTKyDgtky085hqta-Udq91hPRp1PTPBJ3BV5PLR~jDOOTX-Snq8xrlGaO7c4~nhNBaRCbpg__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA.

Templer, K. J., & Lange, S. R. (2008). Internet testing: Equivalence between proctored lab and unproctored field conditions. *Computers in Human Behavior, 24*(3), 1216-1228. https://doi.org/10.1016/j.chb.2007.04.006

Tippins, N. T., Beaty, J., Drasgow, F., Gibson, W. M., Pearlman, K., Segall, D. O., & Shepherd, W. (2006). Unproctored internet testing in employment settings. *Personnel Psychology, 59*(1), 189-225. https://doi.org/10.1111/j.1744-6570.2006.00909.x

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research*, *45*(1), 89-125. https://doi.org/10.3102/00346543045001089

Van Dyken, J., Benson, L., & Gerard, P. (2015). Persistence in engineering: does initial mathematics course matter? Paper presented at the 2015 ASEE Annual Conference & Exposition, Seattle, WA. https://doi.org/10.18260/p.24562

Wollack, J. A., & Fremer, J. (Eds.). (2013). *Handbook of test security.* Routledge.

Woodruff, L. (2013). Security issues in classroom testing. In Wollack, J.A. & Fremer, J. J. (Eds.), *Handbook of test security* (pp. 85-99). Routledge.

Yates, R. W., & Beaudrie, B. (2009). The impact of online assessment on grades in community college distance education mathematics courses. *American Journal of Distance Education*, *23*(2), 62-70. https://doi.org/10.1080/08923640902850601

APPENDIX A

REQUESTED DATA

The data set will include the following specific data points:

Cohort Characteristics

- Admit Type (e.g., standard versus test optional)

Demographic Information

- Race
- Gender
- Pell Grant Status

Academic Information

- SAT/ACT Math Scores with Date
- High School GPA
- College, Program and Major at Time of Admittance
- Change of Major (If Applicable)
- Semester by Semester GPA
- Initial and Second Math Course Taken (Only for courses along the math course sequence- Pre-College Math through Calculus)
    - Year and Term
    - Final Grades (Including Withdrawals, Pass/Fail)
    - Course Type (Online/Hybrid/In-Person)
- Student Status (e.g., Full-Time, Part-Time)

Placement Information

- Auto-Placement
    - Auto-Placement Level (inclusive of statistics placement)
    - Auto-Placement Date
- Proctored versus Unproctored Group Assignment
- ALEKS Tests Taken
    - Date Taken
    - Scores
- Course Placements (inclusive of statistics placement)