AN ANALYSIS OF ELIGIBILITY INDEX IN RELATION TO SUCCESSFUL COMPLETION OF PRE-CALCULUS MATHEMATICS AT CALIFORNIA STATE UNIVERSITY OF LONG BEACH

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Cyna Nguyen

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I, THE UNDERSIGNED MEMBER OF THE COMMITTEE, HAVE

APPROVED THIS THESIS

AN ANALYSIS OF ELIGIBILITY INDEX IN RELATION TO SUCCESSFUL COMPLETION OF PRE-CALCULUS MATHEMATICS AT CALIFORNIA STATE UNIVERSITY LONG BEACH

BY

Cyna Nguyen

Jen-Mei Chang, Ph.D. (Thesis Advisor) **Department of Mathematics & Statistics**

California State University, Long Beach

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ABSTRACT

AN ANALYSIS OF ELIGIBILITY INDEX IN RELATION TO SUCCESSFUL COMPLETION OF PRE-CALCULUS MATHEMATICS AT CALIFORNIA STATE UNIVERSITY OF LONG BEACH

By Cyna Nguyen

This paper analyzes the predictive validity of the placement scheme administered by the California State University system that started in Fall 2020. Since standardized testing is no longer considered for admission at CSULB, the revised STEM Eligibility Index (EI) for incoming freshman is calculated based on students' high school math and science grade point average (GPA). This revised STEM Eligibility Index is used to place incoming students into appropriate mathematics classes. Conditional probability analysis was used to calculate the passing and failing rates for students in the pre-calculus course Essential Algebra A (Math 112A). Students with the minimum Revised STEM EI score of 3600 have an 85.32% chance of successfully completing Math 112A, which is almost a 2-percentage point increase from when the minimum Prior STEM EI score of 3300 was used. A logistic regression model was used to study the impact of students' high school grade point average (GPA), high school math GPA, and high school science GPA on their successful completion of Math 112A. It was determined that the overall high school GPA has the greatest impact on the successful completion of Math 112A. The revised STEM Eligibility Index led to a comparable probability of completion rate in Math 112A compared to the completion rate established in a previous study using the prior STEM Eligibility Index, confirming that standardized test scores hold no significance to the success of students in pre-calculus mathematics Math 112A.

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INTRODUCTION

The CSU Executive Order 1110 was implemented in 2018 and calls for the use of multiple measures to determine course placement for first year college students (CSU, n.d.). Multiple measures is a placement scheme that utilizes students' high school GPA, grades in collegiate courses, high school English and mathematics/quantitative reasoning courses completed and grades earned, ACT, SAT, and/or SAT subject test scores, Advanced Placement (AP) or International Baccalaureate (IB) scores, or Smart Balanced Assessment/Early Assessment Program (EAP) scores to place newly admitted students into appropriate courses (CSU, n.d.). The CSU system has decided to permanently waive standardized test scores (ACT, SAT, and SAT subject test scores) as a requirement for admission. Scores were provided at the discretion of the student and only used as a condition of enrollment for their course placement, but not all students have chosen to report their standardized test scores.

Instead of using the Prior STEM Eligibility Index (EI), which uses standardized test scores, CSULB has switched to using a Revised STEM Eligibility Index, one that only incorporates students high school math and science GPA. The STEM Eligibility Index is the Eligibility Index of interest because students in the pre-calculus mathematics course Essential Algebra A (Math 112A) at CSULB are STEM-bound. The focus of this study is to evaluate factors of multiple measures, particularly high school math and science GPA, in relation to successful completion of Math 112A. Math 112A is the first part of a two-course sequence taken by students who are not ready for Precalculus Algebra (Math 113) and is usually taken with the one-unit corequisite support class Foundations for Essential Algebra (Math 92). Based on local research confected in the Math Department at CSULB, researchers found that Math 112A is a predictor of students' likelihood of later passing Calculus I, which is predicative of student retention in the STEM (Science, Technology, Engineering, and Math) fields. It is important to identify at risk students in Math 112A using the Revised STEM EI to ensure that they are placed into mathematics courses where they are likely to successfully complete.

This study will answer the following question: What is the probability that a student will successfully complete Essential Algebra A (Math 112A) using the minimum Revised STEM Eligibility Index? How does this percentage compare to the range of Prior STEM Eligibility Index for successful completion of Math 112A? What is the relationship of overall high school GPA, high school math GPA, and high school science GPA to the successful completion of Math 112A?

LITERATURE REVIEW

California State University Policy

Due to the COVID-19 pandemic, the California State University system suspended standardized test scores (CAASPP/EAP, ACT, SAT, AP, IB, and CLEP) as part of the admissions process for the 2021-2022 and 2022-2023 academic years (CSU, 2022). Incoming students were no longer required to report standardized test scores, and students had the option to report test scores if desired. The CSU's Admission Advisory Council (AAC) proposed the permanent discontinuation of standardized test scores for CSU undergraduate admissions in January 2022 (CSU, 2022). Since then, the CSU Board of Trustees has voted unanimously to amend Title 5 of the California Code of Regulations, ultimately eliminating standardized tests such as SAT and ACT from the CSU undergraduate admission process (CSU, 2022).

Since the CSU system has eliminated standardized test scores, these scores are no longer considered for freshman course placement. Without standardized testing as a factor for placement means that all the CSU universities must depend on other multiple measures for course placement. In particular, CSULB no longer uses standardized test results and has shifted to using only high school math and high school science GPA to calculate STEM Eligibility Index. This STEM Eligibility Index is paired with the ALEKS PPL assessment to place incoming freshmen into their mathematics courses.

Research done based on multiple measures has found that high school grades are more accurate in predicting student success in math classes rather than placement tests and standardized tests (Bracco et al., 2021). The Executive Order 1110 focuses on high school grades to place students into a math classification and ultimately their freshman year math courses. Research has shown that high school grade point average (GPA) is the strongest predictor of success in freshman courses, and this predictive power becomes even stronger by combining that with other grades and scores, such as high school math grades (Ganga & Mazzariello, 2019).

Multiple Measures

Multiple measures refer to a student's GPA and their mathematical background. For incoming freshman at CSULB, this includes high school math GPA, math SAT score, math SAT II score, math ACT score, ALEKS Mathematics Placement score, high school Calculus AB AP test score, high school Calculus BC AP test score, mathematics higher level IB test score, pre-Calculus CLEP Examination score, and college algebra CLEP Examination score (CSULB CNSM, n.d.). These scores are used to place incoming freshman into an appropriate mathematics course, and students are placed into their mathematics courses based on one of the elements listed.

In a study done by the University of Southern California, it was found that using multiple measures to make mathematics placement decisions has improved course placement accuracy (Ngo & Kwon, 2015). The study utilizes evidence from the Los Angeles Community college District, where many students are placed into mathematics classes based on placement tests. Placement tests are common in many colleges, but they have low predictive validity and have misassigned students to their mathematics courses (Ngo & Kwon, 2015). The findings indicate that by using multiple measures, such as high school GPA and prior high school math experience, placement decisions are improved and more suitable for students' mathematical ability, ultimately ensuring that students will be successful in their mathematics courses.

Students that were placed into a higher-level math course from multiple measures performed the same as their peers who were scoring higher on the placement tests (Ngo & Kwon, 2015). Therefore, a student's score on a placement test is comparable to their high school

GPA or prior mathematical background. By using high school GPA, students are placed into appropriate mathematics courses where they are likely to succeed in the course.

Math Classification

The CSU Executive Order 1110 provides placement thresholds based on placement indicators from students' academic performance and the Early Start Program. This policy applies to students who need to be placed into CSU General Education (GE) in Written Communication (A2) or Mathematics/Quantitative Reasoning (B4). This study will only be about the GE B4 classification, although the GE A2 classification works similarly. By using multiple measures, the Chancellor's office places students into four classifications. At CSULB, Mathematics Classification I students have satisfied the GE B4 quantitative requirement. Classification II students are placed into entry level GE B4 classes without support. Here, support is referring to an additional one-unit corequisite class that provides extra time on task. Classification III students at CSULB are required to take entry level GE B4 classes with support. At CSULB, Classification IV students are required to take entry level GE B4 classes with support and must complete an early start mathematics program in the summer before their attendance.

Math 112A was created in 2019 to cater to Classification III and Classification IV students who have interests in the STEM fields. These students are required to take Math 112A with a one-unit corequisite support class, Foundations for Essential Algebra (Math 92), unless they have scored at least 60 points on the ALEKS Mathematics placement. For the purpose of this study, only Math 112A grades are evaluated.

Mathematics Course Placement

The course sequence of Essential Algebra A (Math 112A) and Essential Algebra B (Math 112B) is intended for students who are not ready for Precalculus Algebra (Math 113). Currently

CSULB uses the ALEKS: Assessment and Learning in Knowledge Spaces PPL mathematics placement to place students into their prospective mathematics courses. Students who score at least 60 on the ALEKS Mathematics Placement are ready to take Math 113. Students who are in Classification III or IV and score below 60 on the ALEKS Mathematics Placement are required to take Math 112A along with the corequisite support class, Math 92. Students who are in Classification II and score below 60 are not required to take Math 92. The reason why mathematics course placement is dependent on multiple factors is because the more accurate the course placement is, the higher probability that a student will successfully complete their mathematics course.

During the 2018 and 2019 academic year at CSULB, the mathematics courses with a DFW rate higher than 15% were mainly calculus courses (GI 2025, 2022). These courses have the most students with a non-passing grade, i.e., grades of D, F, or W. During the 2020 academic year at CSULB, it was found that Math 112A was among the mathematics courses with a DFW rate higher than 15% (GI 2025, 2022). Although there are many factors that attribute to this rate, one of the factors is whether students have been placed into the mathematics course that they are most likely to successfully complete.

Students should not be under-placed nor over-placed in a course, but they should be placed into the highest-level math course that they can successfully complete. It is important to study the successful completion rates of pre-calculus courses, such as Math 112A, to further understand student performance in later mathematics courses. At-risk students will benefit from the extra support and learning communities provided by CSULB. When students successfully complete Math 112A, they will have study skills and mathematical abilities to progress to other math courses, such as Calculus I (Math 122). The successful completion rates of students in pre-calculus courses, such as Math 112A, are a predictive indicator of student retention in STEM.

STEM Eligibility Index

The Prior STEM EI required standardized test scores and high school grade point average (GPA) and is calculated using:

$$\text{(College Preparatory GPA x 600) + SAT Critical Reading Score + (2 x SAT Math Score).} \quad (1)$$

Students who wanted to be admitted as a STEM major were required to have a Prior STEM EI score of at least 3300 (Miller, 2018).

The Revised STEM EI, which has been used since Fall 2021, is calculated using only students' high school (HS) Math and Science GPA. This is calculated by:

$$\text{(HS Math Subject GPA x 600) + (HS Science GPA x 600).} \quad (2)$$

Students who want to be admitted as a STEM major are required to have a Revised STEM EI score of at least 3600 (CSULB, 2021).

While the current Revised STEM EI requires high school science GPA, the regular CSULB Index does not require high school science GPA. The regular CSULB Index is:

$$\text{(College Preparatory GPA x 200) + (500 x HS Math GPA) + (500 x HS English GPA).} \quad (3)$$

METHODOLOGY

Extension of Research

This study incorporates the same methodologies of Kirsten Miller's 2018 Honors Thesis to the CSULB Prior STEM EI and the Revised STEM EI. It is an extension of her research to examine the validity of the CSULB math placement scheme based solely upon math high school GPA and science high school GPA, rather than the CSULB Mathematics ALEKS Placement scores. This is evaluated for students in Essential Algebra A (Math 112A) instead of students in Precalculus Algebra (Math 113). The analysis techniques used by Miller (2018) of conditional probability, calculating failure rates, and evaluating logistic regression are used in this project.

Data Collection

Before receiving the collection of data, this study was approved by the CSULB Institutional Review Board (IRB). The data was then provided by the CSULB Institutional Research and Analytics (IR&A). The information provided for this study consists of first time, first year students' overall high school GPA, high school math GPA, high school science GPA, SAT score, ACT score, regular Eligibility Index calculated based on the formula at the time of entry, STEM Eligibility Index, final grade in Math 112A, final grade in Math 92, and math classification. The data set has been de-identified to ensure confidentiality. The data will be used for the analysis techniques of conditional probability analysis, evaluating failure rates, and logistic regression.

The data set consists of students who were officially enrolled and declared as a pre-STEM or STEM major when admitted in 2018, 2019, and 2020. Out of these students, 340 students were enrolled in Math 112A in Fall 2018, 93 students were enrolled in Math 112A in Spring 2019, 734 students were enrolled in Math 112A in Fall 2019, 140 students were enrolled in Math 112A in Spring 2020, and 569 students were enrolled in Math 112A in Fall 2020. In the process of preparing the data, only the entry from students' first-time taking Math 112A was kept, regardless of their completion status. This is to ensure that the data is consistent in evaluating the Math 112A completion rate. There were cases where students took the course multiple times, but for this study, only the information when a student first took Math 112A was used to avoid multiple grade entries. In total, there were 1179 data points that were used.

Data Preparation

Before starting any analysis, the data set was prepared through Excel and MATLAB codes. Successful completion of Math 112A is one of the binary outcomes of students' final grades. Students who have received a grade of A, B, C or CR in Math 112A and Math 92 were categorized as passing. Students who received a grade of D, F, NC, W, WU, or Math 112A and Math 92 were categorized as failing. For the purpose of coding, passing grades were labeled as 1, while failing grades were labeled as 0.

The following analysis techniques incorporates students' high school math GPA, high school science GPA, and final grades in Math 112A. It also compares the data between Prior STEM EI Scores with the Revised STEM EI scores. The Prior STEM EI scores were calculated in Excel using students' college preparatory GPA, SAT critical reading score, and SAT math score (see Equation (1)). Pivot values for the Prior STEM EI were between the range of 2840 to 4465 and differed by an increment of 65 each time. There was a total of 26 pivot values for the Prior STEM EI. Pivot values for the Revised STEM EI scores were between the range of 1900 to 5000 and differed by an increment of 124 each time. The increment value of 124 was chosen so that the total number of pivot values for Revised STEM EI was also 26. Both the Prior STEM EI and Revised STEM EI have the same amount of pivot scores for the purpose of numerical and graphical comparison.

Conditional Probability Analysis

The method of conditional probability analysis calculates the probability of an event given that other events have occurred. The conditional probability equation is:

$$P(A|B) = \frac{P(A \cap B)}{P(B)} \quad \text{, provided that } P(B) > 0. \tag{4}$$

A MATLAB code was used to determine: the conditional probability of a student passing Math 112A if their STEM Eligibility Index score was greater than or equal to a specified pivot value, and the conditional probability of a student failing Math 112A if their STEM Eligibility Score was lower than a specified pivot value. Using the conditional probability equation, in the first case, A = a passing grade in Math 112A, and B = the eligibility index being great than or equal to the pivot value. In the second case, A = a failing grade in Math 112A, and B = the eligibility index being less than or equal to the pivot value. Both cases were performed using the Prior STEM EI and the Revised STEM EI. This analysis was done 26 times to the 26 pivot values. In the case of the Revised STEM EI, the pivot values started at 1900 and increased by 124, ending at 5000. For the Prior STEM EI, the pivot values started at 2840 and increased by 65, ending at 4465.

This analysis was performed to confirm that the probability of successful completion of Math 112A increases as the pivot values of STEM EI increased. Similarly, the probability of a student failing Math 112A increases as the pivot values of STEM EI decreases. This was true for both the Revised STEM EI and Prior STEM EI.

Failure Rates

The failure rate of STEM EI was calculated by dividing the total number of students who failed Math 112A by the total number of students that took Math 112A in a particular interval.

Failure rate (FR) was calculated using:

$$FR = \frac{\text{Number of Students that failed Math 112A in a specified range}}{\text{Total Number of Students that took Math 112A in a specified range}} \tag{5}$$

A lower failure rate corresponds to a higher STEM EI score. The assumption is that as the STEM EI scores decrease, the failure rates will increase. This will be done for both the Prior STEM EI and Revised STEM EI. Since there were 26 pivots for both the Prior STEM EI and Revised STEM EI, there were a total of 25 intervals for both since every interval requires 2 pivot values.

Logistic Regression

To determine the impact of overall high school GPA, high school Math GPA, and high school science GPA on a student's probability of successful completion of Math 112A, a logistic regression model was used:

$$\text{Logit}\,[P(Y)] = \alpha + \beta_1\,(\text{High School GPA}) + \beta_2\,(\text{High School Math GPA}) + \beta_3\,(\text{High School Science GPA}) \tag{6}$$

Logistic regression is a type of mathematical modeling that analyzes the impact of multiple independent variables to a dichotomous dependent variable (Kleinbaum & Klein, 2010). Math 112A status is the dependent variable, while high school GPA, high school math GPA, and high school science GPA are the independent variables. The unknown parameters α and the $\beta_i's$ will be calculated through MATLAB. These parameters will help provide the probability that a student will pass Math 112A based on their GPAs.

Using a revised version of Kirsten Miller's 2018 MATLAB code, the numerical coefficients were found for α, β_1, β_2, and β_3. These coefficients were paired with students' overall high school GPA, high school math GPA, and high school science GPA to calculate their probability of passing Math 112A.

RESULTS

Conditional Probability Analysis

The conditional probability of success in Math 112A given that a student has a Revised STEM EI score greater than or equal to the pivot value is displayed in Table 1. The data supports the prediction that the probability of success increases as the Revised STEM EI increases. The only exceptions are at the pivots 4380 and 4628, which can be observed in Figure 1. Despite the slight decrease in probability, the probability of success is still very high. Students who attain or exceed the minimum Revised STEM EI score of 3600 will have an 85.32% chance of successfully completing Math 112A.

In the case of the Prior STEM EI score, the probability of success in Math 112A also increases as the pivot score of the Prior STEM EI increases (see Table 2). The only exception is at the pivot 4075, which can be observed in Figure 2. Although the probability is slightly lower than the probability of the pivot before it, it is still very high. Students who attain or exceed the Prior STEM EI score of 3295 will have at least an 83.73% chance of successfully completing Math 112A. For the pivot score of 3360, students will have an 85.34% chance of successfully completing Math 112A. When the Prior STEM EI (see Equation (1)) was used, incoming freshman were required to have a score of at least 3300. The pivot values of 3295 and 3360 were chosen for discussion since they were the values closest to the Prior STEM EI cut score of 3300. Since 3300 falls between the pivots of 3295 and 3360, then it is assumed that if a student has a minimum Prior STEM EI of 3300, they will also have at least an 83.73% chance of successfully completing Math 112A.

The conditional probability of failure in Math 112A given that a student has a Revised Eligibility Index score less than or equal to the pivot value is displayed in Table 3 and Table 4.

The data also confirms the prediction that the conditional probability of failure would decrease as the pivot values increase. This holds true for both the Revised STEM EI and the Prior STEM EI, and the data is displayed graphically in Figure 3 and Figure 4.

Revised STEM Eligibility Index (EI) Pivot	Number of Students with Revised STEM EI Above Pivot	Conditional Probability of Success	Probability as Percentage
1900	1179	0.7897	78.97%
2024	1178	0.7903	79.03%
2148	1178	0.7903	79.03%
2272	1175	0.7898	78.98%
2396	1170	0.7897	78.97%
2520	1159	0.7886	78.86%
2644	1140	0.7921	79.21%
2768	1113	0.7952	79.52%
2892	1062	0.8032	80.32%
3016	976	0.8187	81.87%
3140	907	0.8214	82.14%
3264	789	0.8314	83.14%
3388	667	0.8381	83.81%
3512	556	0.8417	84.17%
3636	470	0.8532	85.32%
3760	385	0.8753	87.53%
3884	317	0.8896	88.96%
4008	240	0.9042	90.42%
4132	187	0.9251	92.51%
4256	123	0.935	93.5%
4380	95	0.9263	92.63%
4504	56	0.9643	96.43%
4628	37	0.946	94.6%
4752	23	0.9565	95.65%
4876	3	1	100%
5000	0		

Table 1. Numerical values from the conditional probability analysis for success in Math 112A using the Revised STEM EI.

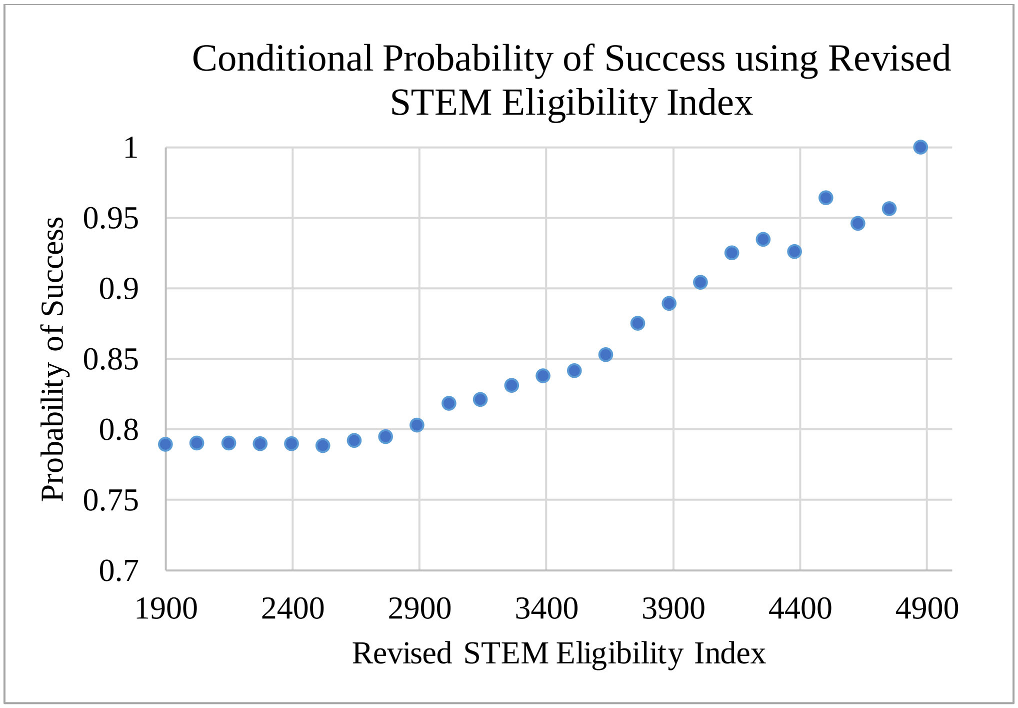

Figure 1. Graphical representation of conditional probability of success using the Revised STEM Eligibility Index.

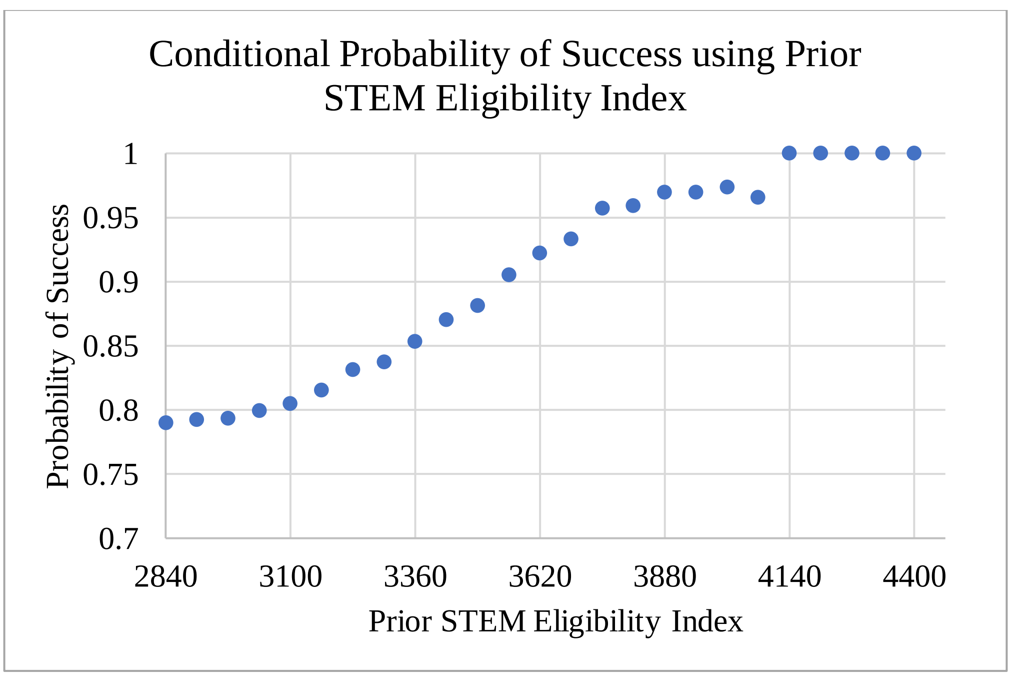

Figure 2. Graphical representation of conditional probability of success using the Prior STEM Eligibility Index.

Prior STEM Eligibility Index (EI) Pivot	Number of Students with Prior STEM EI Above Pivot	Conditional Probability of Success	Probability as a Percentage
2840	1179	0.7897	78.97%
2905	1174	0.7922	79.22%
2970	1171	0.7933	79.33%
3035	1152	0.7995	79.95%
3100	1113	0.8050	80.5%
3165	1061	0.8153	81.53%
3230	996	0.8313	83.13%
3295	928	0.8373	83.73%
3360	798	0.8534	85.34%
3425	693	0.8701	87.01%
3490	590	0.8814	88.14%
3555	454	0.9053	90.53%
3620	373	0.9223	92.23%
3685	285	0.9333	93.33%
3750	209	0.9569	95.69%
3815	172	0.9593	95.93%
3880	132	0.9697	96.97%
3945	99	0.9697	96.97%
4010	75	0.9733	97.33%
4075	58	0.9655	96.55%
4140	31	1	100%
4205	16	1	100%
4270	12	1	100%
4335	6	1	100%
4400	3	1	100%
4465	0		

Table 2. Numerical values from the conditional probability analysis for success in Math 112A using the Prior STEM EI.

Revised STEM Eligibility Index (EI) Pivot	Number of Students with Revised STEM EI Below Pivot	Conditional Probability of Failure	Probability as Percentage
1900	0		
2024	1	1	100%
2148	1	1	100%
2272	4	0.25	25%
2396	9	0.2222	22.22%
2520	20	0.15	15%
2644	39	0.2821	28.21%
2768	66	0.303	30.3%
2892	117	0.3333	33.33%
3016	203	0.3498	34.98%
3140	272	0.3162	31.62%
3264	390	0.2949	29.49%
3388	512	0.2734	27.34%
3512	623	0.2568	25.68%
3636	709	0.2525	25.25%
3760	794	0.2519	25.19%
3884	862	0.2471	24.71%
4008	939	0.2396	23.96%
4132	992	0.2359	23.59%
4256	1056	0.2273	22.73%
4380	1084	0.2223	22.23%
4504	1123	0.2191	21.91%
4628	1142	0.2154	21.54%
4752	1156	0.2137	21.37%
4876	1176	0.2109	21.09%
5000	1179	0.2104	21.04%

Table 3. Numerical values from the conditional probability analysis for failure in Math 112A using the Revised STEM EI.

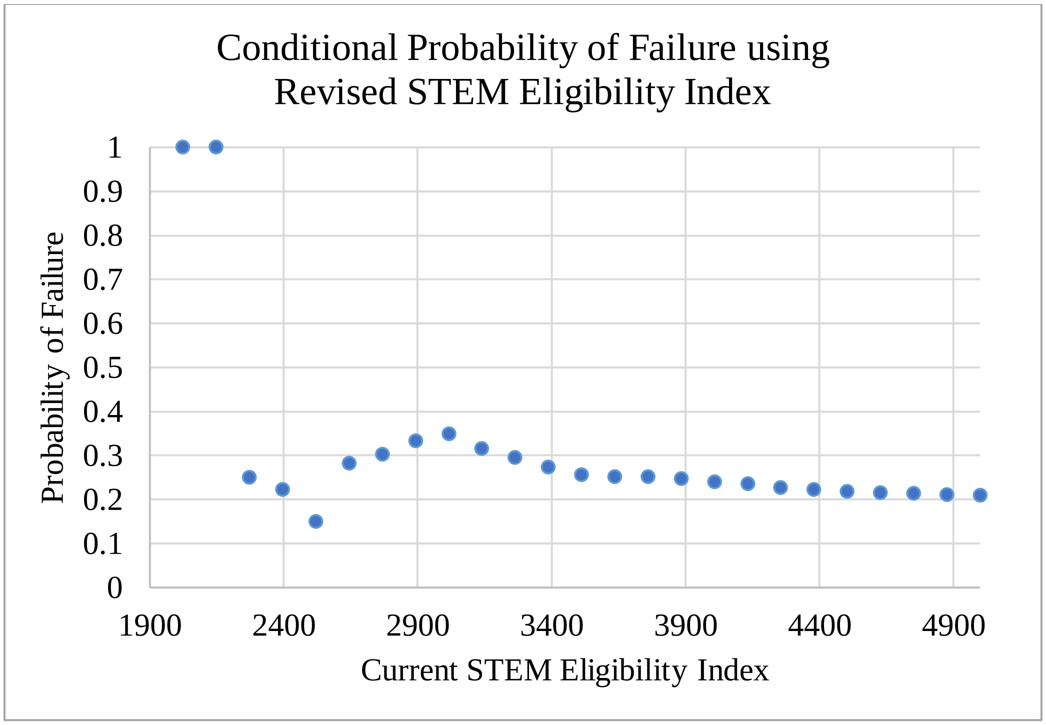

Figure 3. Graphical Representation of Conditional Probability of Failure in Math 112A using Revised STEM Eligibility Index.

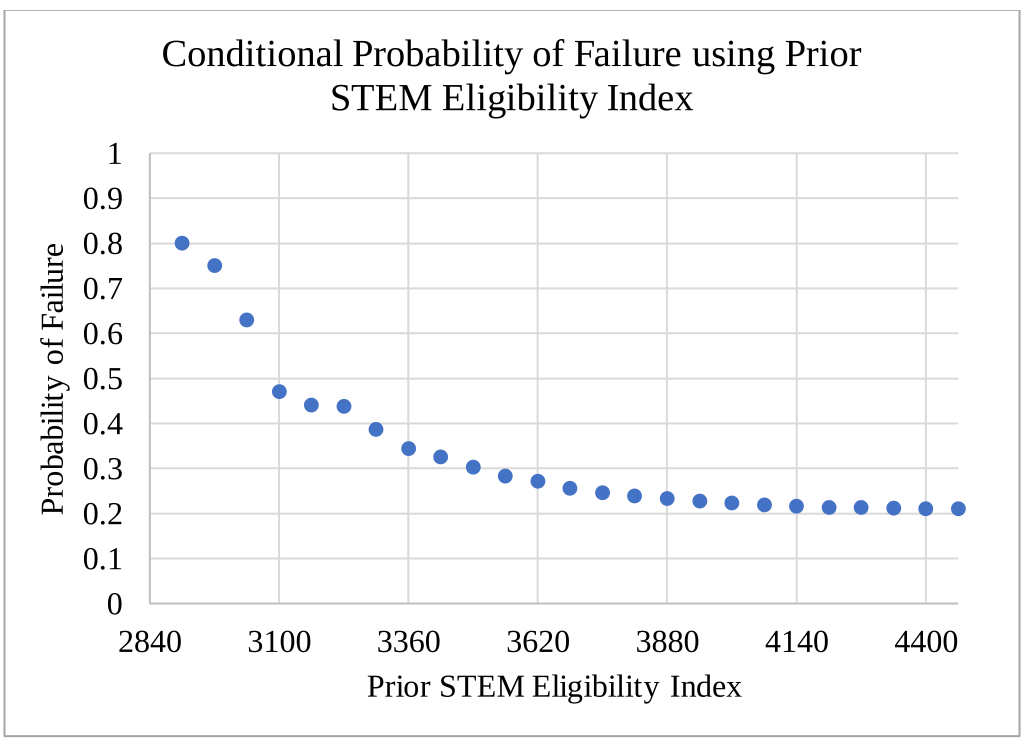

Figure 4. Graphical Representation of Conditional Probability of Failure in Math 112A using Prior STEM Eligibility Index.

Prior STEM Eligibility Index (EI) Pivot	Number of Students with Prior STEM EI Below Pivot	Conditional Probability of Failure	Probability as a Percentage
2840	0		
2905	5	0.8	80%
2970	8	0.75	75%
3035	27	0.6296	62.96%
3100	66	0.4697	46.97%
3165	118	0.4407	44.07%
3230	183	0.4372	43.72%
3295	251	0.3865	38.65%
3360	381	0.3438	34.38%
3425	486	0.3251	32.51%
3490	589	0.3022	30.22%
3555	725	0.2828	28.28%
3620	806	0.2717	27.17%
3685	894	0.2562	25.62%
3750	970	0.2464	24.64%
3815	1007	0.2393	23.93%
3880	1047	0.233	23.3%
3945	1080	0.2269	22.69%
4010	1104	0.2228	22.28%
4075	1121	0.2194	21.94%
4140	1148	0.216	21.6%
4205	1163	0.2132	21.32%
4270	1167	0.2125	21.25%
4335	1173	0.2114	21.14%
4400	1176	0.2109	21.09%
4465	1179	0.2103	21.03%

Table 4. Numerical Values from the conditional probability of failure in Math 112A using the Prior STEM Eligibility Index.

Failure Rates

Table 5 and Table 6 are the numerical values from the failure rates of Math 112A over the 25 Revised STEM EI intervals and the 25 Prior STEM EI intervals.

Revised STEM Eligibility Index (EI) Range	Number of Students with Revised STEM EI in the Range	Revised STEM EI Failure Rate	Failure Rate as Percentage
1900 - 2024	1	1	1
2024 - 2148	0	0	0%
2148 - 2272	3	0	0%
2272 - 2396	5	0.2	20%
2396 - 2520	11	0.0909	9.09%
2520 - 2644	19	0.4211	42.11%
2644 - 2768	27	0.3333	33.33%
2768 - 2892	51	0.3725	37.25%
2892 - 3016	86	0.3721	37.21%
3016 - 3140	69	0.2174	21.74%
3140 - 3264	118	0.2458	24.58%
3264 - 3388	122	0.2049	20.49%
3388 - 3512	111	0.1802	18.02%
3512 - 3636	86	0.2209	22.09%
3636 - 3760	85	0.2471	24.71%
3760 - 3884	68	0.1912	19.12%
3884 - 4008	77	0.1558	15.58%
4008 - 4132	53	0.1698	16.98%
4132 - 4256	64	0.0938	9.38%
4256 - 4380	28	0.0357	3.57%
4380 - 4504	39	0.1282	12.82%
4504 - 4628	19	0	0%
4628 - 4752	14	0.0714	7.14%
4752 - 4876	20	0.05	5%
4876 - 5000	3	0	0%

Table 5. Numerical values from the failure rate analysis using Revised STEM EI.

Prior STEM Eligibility Index (EI) Range	Number of Students with Prior STEM EI in the Range	Prior STEM EI Failure Rate	Failure Rate as Percentage
2840 - 2905	5	0.8	80%
2905 - 2970	3	0.6667	66.67%
2970 - 3035	19	0.5789	57.89%
3035 - 3100	39	0.359	35.9%
3100 - 3165	52	0.4038	40.38%
3165 - 3230	65	0.4308	43.08%
3230 - 3295	68	0.25	25%
3295 - 3360	130	0.2615	26.15%
3360 - 3425	105	0.2571	25.71%
3425 - 3490	103	0.1942	19.42%
3490 - 3555	136	0.1985	19.85%
3555 - 3620	81	0.1728	17.28%
3620 - 3685	88	0.1136	11.36%
3685 - 3750	76	0.1316	13.16%
3750 - 3815	37	0.0541	5.41%
3815 - 3880	40	0.075	7.5%
3880 - 3945	33	0.0303	3.03%
3945 - 4010	24	0.0417	4.17%
4010 - 4075	17	0	0%
4075 - 4140	27	0.0741	7.41%
4140 - 4205	15	0	0%
4205 - 4270	4	0	0%
4270 - 4335	6	0	0%
4335 - 4400	3	0	0%
4400 - 4465	3	0	0%

Table 6. Numerical values from the failure rate analysis using the Prior STEM EI.

As predicted, the failure rates decreased as both the Revised STEM EI and Prior STEM EI scores increase. With a few exceptions, the overall trend of the failure rates was as predicted (see Figure 5 and Figure 6).

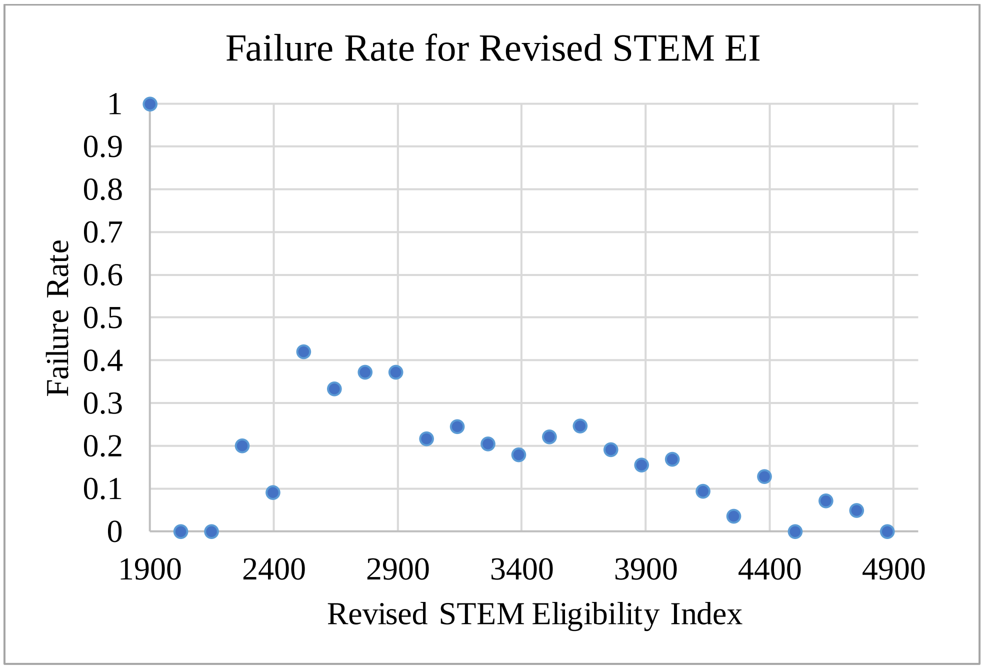

Figure 5. Graphical representation of failure rate for Revised STEM EI.

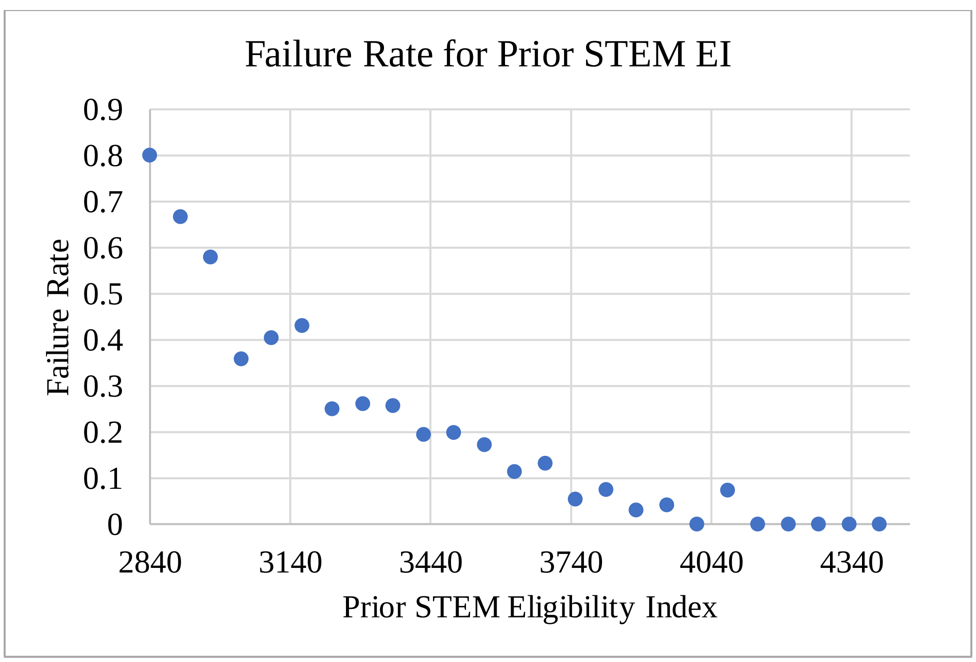

Figure 6. Graphical representation of failure rate for Prior STEM EI.

Logistic Regression

Using a revised version of Kirsten Miller's 2018 MATLAB code, a logistic regression model (see Equation (4)) was used to analyze the impact of overall high school GPA, high school math GPA, and high school science GPA on a student's probability of successful completion of Math 112A. As mentioned before, the coefficients of α, β_1, β_2, and β_3 were paired with students' high school GPA, high school math GPA, and high school science GPA.

The logistic regression analysis computed the following:

$$\alpha = -5.7141, \quad \beta_1 = 1.9086, \quad \beta_2 = 0.4935, \text{ and } \beta_3 = -0.2517.$$

The regression model became:

Logit [P(Y)] = −5.7141 + 1.9086 (High School GPA) + 0.4935 (High School Math GPA) + −0.2517 (High School Science GPA).

The value of $\beta_1 = 1.9086$ indicates the impact of overall high school GPA on the status of Math 112A. Taking the unit change in overall high school GPA to be 0.1, every time a student's GPA increases by 0.1, the probability of that student passing Math 112A increases by 19%. If the unit change is 0.25, then the probability of passing Math 112A increases by 47.7%. If the unit change is 0.5, then the probability of passing Math 112A increases by 95.4%. The data confirms that by increasing overall high school GPA, a student will also increase their likelihood of passing Math 112A.

The value of $\beta_2 = 0.4935$ indicates the impact of high school math GPA on the status of Math 112A. Taking the unit change in high school math GPA to be 0.1, every time a student's GPA increases by 0.1, the probability of that student passing Math 112A increases by 4.9%. If the unit change is 0.25, then probability of passing Math 112A increases by 12.3%. If the unit change is 0.5, then the probability of passing Math 112A increases by 24.7%. Like overall high school GPA, high school math GPA is also significant in the probability of passing Math 112A.

The value of $\beta_3 = -0.2517$ indicates the impact of high school science GPA on the status of Math 112A. Since this value is negative, this means that no matter what we take our unit change to be, high school science GPA does not have an impact on a student's status of Math 112A. This might offer a small glimpse into why the CSULB Chancellor's office does not consider high school science GPA for freshman admission. The regular CSULB Index is calculating using overall high school GPA, high school math GPA, and high school English GPA (see Equation (3)). The STEM Eligibility Index requires high school math and science GPA. Although, to determine the probability of passing Math 112A, high school math GPA plays a more significant role than high school science GPA.

CONCLUSION

Because of the COVID-19 pandemic, the STEM Eligibility Index has been revised from what it was prior to the pandemic. Since the Revised STEM EI only considers GPA, it is important to compare it with the Prior STEM EI to see if that probability of a student passing Math 112A corresponds. The Revised STEM EI is the only STEM EI that CSULB uses.

The first two questions of this study were: What is the probability that a student will successfully complete Essential Algebra A (Math 112A) using the minimum revised STEM Eligibility Index? How does the percentage compare to the range of Prior STEM Eligibility Index for successful completion of Math 112A?

Using the cut score of 3300 for the Prior STEM EI, the data revealed that students would have an 83.73% chance of passing Math 112A. For the score of 3600 for Revised STEM EI, the data revealed that students would have about an 85.32% chance of passing Math 112A. When comparing the two, the percentage of successfully completing Math 112A using the Prior STEM EI is about 1.57 percentage points lower than when the Revised STEM EI is used. To have at least an 85% chance of passing Math 112A using the Prior STEM EI, students would need a score of at least 3360 (see Table 2). By using the Revised STEM EI minimum score of 3600, incoming freshman students have a slightly higher chance of successfully completing Math 112A than if the Prior STEM EI was used. The current range of Revised STEM EI that CSULB uses, i.e., scores of at least 3600, will ensure that students have at least an 83.73% chance of successfully completing Math 112A.

The third question of this study was: What is the relationship of overall high school GPA, high school math GPA, and high school science GPA to the successful completion of

Math 112A?

By using the logistic regression model, it was determined that overall high school GPA had the largest impact on Math 112A outcome. For every 0.1 increase of overall high school GPA, a student's probability of successfully completing Math 112A increased by 19%. When high school math GPA was evaluated, it was determined that for every 0.1 increase of high school math GPA, a student's probability of successfully completing Math 112A increased by 4.9%. There is about a 15-percentage point difference when comparing the impact of overall high school GPA and high school math GPA. Although high school math GPA would seem to have a larger impact on a student's success in Math 112A, that was not the case. When evaluating the impact of high school science GPA on a student's probability of success completing Math 112A, there was no impact. This means that high school science GPA does not affect a student's academic performance in Math 112A.

When standardized test scores are taken out of multiple measures in placing freshman students into appropriate mathematics classes, more weight falls onto high school mathematics and science GPA. In the case of this study that focuses on Math 112A at CSULB, it was found that the Revised STEM Eligibility Index provides a higher probability of a student passing Math 112A using the minimum score of 3600 compared to the minimum Prior STEM Eligibility Index. By continuing to use the minimum score of 3600, students will have an 85.32% chance of successfully completing Math 112A.

FUTURE RESEARCH

Essential Algebra A (Math 112A) is a part of the Essential Algebra course sequence that includes Essential Algebra B (Math 112B), which is taken in the subsequent semester. Since this research project only focuses on Math 112A, this study may be repeated using Math 112B information. Since the STEM Eligibility Index has been revised, it will be useful to conduct a similar study using Math 112B grades to see if the conclusions will be the same.

The Essential Algebra course sequence also includes co-requisite classes. Math 112A is taken with Foundations for Essential Algebra A (Math 92) and Math 112B is taken with Foundations for Essential Algebra B (Math 92B). It will be useful to extend this study to incorporate Math 92 and Math 92B information to evaluate the impact on successful completion of Math 112A and Math 112B.

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SOURCE CODE

The following MATLAB codes have been modified from Kirsten Miller's research in 2018.

Listing 1: Data Preparation

The following code was written to prepare the data set from the .csv file provided from IR&A. The data was then saved in the database 'z' and used for the later codes.

```
clear; clc; format compact

X= readtable('MergedDataFilenew.xlsx','Sheet','MergedFile','ReadVariableNames',false);
data = double(X{:,[5,6,11,12]});

%The following columns are from the Excel file "MergedDataFilenew",
%column 5: Math 92 Enrolled (0 if not taken, 1 for taken)
%column 6: Math 92 Status (0 for fail, 1 for pass)
%column 11: Math 112A Status (0 for fail, 1 for pass)
%column 12: Revised STEM EI

y1 = [];
%students who took Math 92 and Math 112A regardless of completion status
for i = 1:size(data,1)
     if data(i,1)== 1 && (data(i,3) == 1 || data(i,3)== 0)
        y1 = [y1 ; data(i,:)];
    end
end

 y2 = [];
%students who passed Math 92 and took Math 112A
 for i = 1:size(data,1)
      if data(i,2)== 1 && (data(i,3) == 1 || data(i,3)== 0)
         y2 = [y2 ; data(i,:)];
     end
 end

 y3 = [];
%students who passed Math 92 and passed Math 112A
 for i = 1:size(data,1)
      if data(i,2)== 1 && data(i,3) == 1
         y3 = [y3 ; data(i,:)];
     end
 end

% Kept only the first entry for each student that took Math 112A,since some
% students took the class in multiple semesters.
 z = [];
 for i = 2:size(data,1)
     if ~isequal(X{i,1},X{i-1,1})
         if data(i,3)==1
             z = [z; data(i,:)];
         end
     end
 end

save database z;
```

Listing 2: Conditional Probability

This code calculates the conditional probability of a student passing Math 112A and the conditional probability of them failing Math 112A based on specified pivot scores.

```
clear; clc; format compact

X= readtable('MergedDataFilenew.xlsx','Sheet','Sheet1','ReadVariableNames', false);
z = double(X{:,[11,13]}); %This was for the Prior STEM EI.
%^For Revised STEM EI, z = double(X{:,[11,12]});


%The column values for taken from the Excel file "MergedDataFilenew".
%column 12: Revised STEM EI
%column 13: Prior STEM EI

pivot= 1900:124:5000; %This pivot was for Prior STEM EI.
%For Revised STEM EI, pivot = 2500:100:5000;

%The pivot increments were chosen so that both the Prior STEM EI and
%Revised STEM EI both have 26 pivot values. This was purposely done
%for graphical and comparative purposes.

DScount=zeros(length(pivot),1);

for j = 1:length(pivot)
    NS = 0; %initializes the numerator in the success case
    DS = 0; %initializes the denominator in the success case
    NF = 0; %initializes the numerator in the failure case
    DF = 0; %initializes the denominator in the failure case
    count = 0;
    for i = 1:size(X,1)
        if X{i,11} == 1 && X{i,12} >= pivot(j)
            %intersection of passing Math 112A and EI score
            %greater than or equal to the pivot
            NS = NS + 1;

        end
        if X{i,12} >= pivot(j)
            %tests for an EI score greater than or equal to the pivot
            DS = DS + 1;
        end
        if X{i,11} == 0 && X{i,12} < pivot(j)
            %intersection of failing Math 112A and an EI
            %score less than the pivot
            NF = NF + 1;
        end
        if X{i,12} < pivot(j)
            %tests for an EI score less than the pivot
            DF = DF + 1;
        end
    end

    %converting into probabilities
        PNS = NS/size(X,1);
        PDS = DS/size(X,1);
        PNF = NF/size(X,1);
        PDF = DF/size(X,1);

        DScount(j) = DS;
        PS(j) = PNS/PDS; %conditional probability for the passing case
        PF(j) = PNF/PDF; %conditional probability for the failing case
end
```

Listing 3: Failure Rates

The following code calculates Math 112A failure rates for specified intervals.

```
clear; clc; format compact

%The following columns contain the data needed from the
%Excel file "MergedDataFilenew".
%column 11: Math 112A Status (0 for fail, 1 for pass)
%column 12: Revised STEM Eligibility Index
%column 13: Prior STEM Eligibility Index

X= readtable('MergedDataFilenew.xlsx','Sheet','Sheet1','ReadVariableNames', false);
z = double(X{:,[11,12]});

ranges = 1900:124:5000; %The range for Prior STEM EI.
%For the Revised STEM EI, the ranges = 2500:100:5000;

for j = 1:size(ranges,2)-1
    NF = 0;
    DF = 0;
    %initializes numerators and denominators for failure rates
    for i = 1:size(X,1)
        if X{i,13} >= ranges(j) && X{i,13} < ranges(j+1) && X{i,11} == 0
            %finds the total amount of students who have an EI
            %score in a particular range and did not pass Math 112
            NF = NF + 1;
        end
        if X{i,13} >= ranges(j) && X{i,13} < ranges(j+1)
            %finds the total amount of students with a EI score
            %in a particular range
            DF = DF + 1;
        end
    end
    FR(j) = NF/DF
    %Calculates the failure rate for students with a  EI score in a
    %particular range
    D(j)=DF
End
```

Listing 4: Logistic Regression

The following code uses high school overall GPA, high school math GPA, and high school GPA to find the regression coefficients to analyze the impact of these variables on the probability of passing Math 112A.

```
X= readtable('MergedDataFilenew.xlsx','Sheet','MergedDataFile','ReadVariableNames',false);
z = double(X{:,[14,16,15,11]});

%Taking the data needed from the Excel file "MergedDataFilenew"
%column 11: Math 112A Status (0 for fail, 1 for pass)
%column 14: Highschool overall GPA
%column 15: Highschool Science GPA
%column 16: Highschool Math GPA

predictors = [z(:,1), z(:,2), z(:,3)];
outcome = categorical(z(:,4));
[B,dev,stats] = mnrfit(predictors,outcome,'model','nominal')

coefficients = [-B(2,1), -B(3,1), -B(4,1)];
%The coefficients are negative since we are taking the absolute value of
%the betas and taking the opposite value of alpha. By justification from
%Kirsten Miller (2018), "an x unit decrease in the log odds of failing
%correspond with an x unit increase in the log odds of passing in the case
%where only 2 outcomes are possible". The outcomes here are 0 for failing
%Math 112A, and 1 for passing the course.


display('High School GPA')
hsGPAChange = [0.1 0.2 0.25 0.5 1 1.1 1.2 1.25];
%Finding the impact of GPA change on the probability of a student
%successfully completing Math 112A for each increasing increment.
for i = 1:length(hsGPAChange)
    LogOddsChange = coefficients(1)*hsGPAChange(i)
    OddsChange = exp(LogOddsChange)
end

display('High School Math GPA')
mGPAChange = [0.1 0.2 0.25 0.5 1 1.1 1.2 1.25];
for i = 1:length(mGPAChange)
    LogOddsChange = coefficients(2)*mGPAChange(i)
    OddsChange = exp(LogOddsChange)
end

display('High School Science GPA')
sGPAChange = [0.1 0.2 0.25 0.5 1 1.1 1.2 1.25];
for i = 1:length(sGPAChange)
    LogOddsChange = coefficients(3)*sGPAChange(i)
    OddsChange = exp(LogOddsChange)
end
```