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To cite this article:

Navarra-Madsen, J. (2025). Deciphering baseline rates in developmental mathematics education through the lenses of justice, equity, diversity, and inclusion. *International Journal of Studies in Education and Science (IJSES), 6*(1), 19-28. https://doi.org/10.46328/ijses.132

IJSES International Journal of Studies in Education and Science
2025, Vol. 6, No. 1, 19-28 https://doi.org/10.46328/ijses.132

Deciphering Baseline Rates in Developmental Mathematics Education Through the Lenses of Justice, Equity, Diversity, and Inclusion

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Article Info

Article History

Received:
10 February 2024
Accepted:
10 October 2024

Keywords

Developmental mathematics
Best remediation practices
College readiness
Persistence rates
Corequisite courses
Equity

Abstract

Around fifty-five and twenty-three percent of US students entering two-year community colleges and four-year higher education institutions, respectively, are not ready for college courses. This process is quite costly, costing up to an estimated $7.5 billion a year. This retrospective research project will focus on Developmental Mathematics Education at Texas Woman's University, the largest university system focused on women as well as a Hispanic-Serving Institution. A decade-long developmental mathematics education data set is used to decipher the baseline rates such as pass rates (with grades A, B, C), fail (F) and withdrawal rates (W). Statistical analyses such as exploratory data analysis and trend analysis will be employed. Equity-minded and inclusive institutional practices are presented. This paper reports a few equity-minded research-based practices that had a tremendous positive influence to increase the success of almost all DME students at TWU.

Introduction

An increasing number of college-bound students are not quite ready to tackle college level courses. Scott-Clayton, Crosta, and Belfield, and Huff (Scott-Clayton, Crosta, & Belfield, 2014, Huff, 2017) reported that about fifty percent of community college students around the country were considered not prepared to do college-level courses. More than half of community college students failed to meet college-readiness standards in mathematics (Schudde & Keisler, 2019, Meiselman & Schudde, 2022,). Several reforms coming from both the state and higher education institutions have been proposed. One of the currently state-mandated programs is called the Texas Success Initiative (TSI). This policy requires all students who attend Texas public higher education institutions as of Fall 2003 (Texas Education Code §51.3062) to pass the TSI Assessment (TSIA1) unless they are exempted. The TSIA1 has a new version as of January 11, 2021, called the TSIA2, where students are tested using 2 sections: "Mathematics", and "English Language and Reading". Table 1 describes the required scores for both TSIA1 and TSIA2 to be considered college ready. For a student to be deemed ready for college courses in mathematics, a TSIA2 score of 950 or higher on mathematics college readiness classification (CRC) is required. If this student scores below 950, then a score of 6 on the diagnostic test is required for this student to be allowed to register for a college-credit bearing mathematics course. If this student's diagnostic test score is below 6, then the admission officer will likely place this student in one of the developmental mathematics courses that is supposed to improve the student's mathematical skills in a semester or two.

At Texas Woman's University (TWU), developmental mathematics education (DME) means curricular offerings of two mathematics remediation courses, MATH 1113 (Fundamentals of Algebra) and MATH 1123 (Transition to College Mathematics) for students who fail the TSIA1 or TSIA2 and Diagnostic Test. See Table 1.

Table 1. TSIA/TSIA2 Score Requirements for College, Career, and Military Readiness

Subject	Assessment Version	Score Requirements for CCMR				
English Language Arts and Reading (ELAR)	TSIA1	Score ≥ 351 on Reading				
	TSIA2	Score ≥ 945 on the ELAR College Readiness Classification (CRC)	AND		Score ≥ 5 on the essay	
		OR				
		Score < 945 on the ELAR CRC	AND	Score ≥ 5 on the diagnostic	AND	Score ≥ 5 on the essay
	Combination	Score ≥ 945 on the ELAR CRC on the TSIA2	AND		Score ≥ 5 on the TSIA1 essay	
		OR				
		Score < 945 on the ELAR CRC on the TSIA2	AND	Score ≥ 5 on the diagnostic on the TSIA2	AND	Score ≥ 5 on the TSIA1 essay
Mathematics	TSIA1	Score ≥ 350 on Mathematics				
	TSIA2	Score ≥ 950 on the Mathematics CRC				
		OR				
		Score < 950 on the Mathematics CRC	AND	Score = 6 on the diagnostic		

Adapted from Texas Education Agency, Governance and Accountability, Performance Reporting

Significance of the Study

Based on the News and Highlights article from Loyola University Maryland Loyola University (2021), "educational technology is the field of study that investigates the process of analyzing, designing, developing, implementing, and evaluating the instructional environment, learning materials, learners, and the learning process in order to improve teaching and learning." Deciphering institutional baselines rates such as completion, graduation, and other important higher education DME rates is beneficial and valuable not only to the instructors, institution, but also to the students themselves, local communities, state, and federal officials. To be able to furnish and report baseline success rates as well as effective practices and procedures to higher education personnel, administrators, and officials, one solution is to collect institutional data and start gleaning important information from them. Additionally, it is highly recommended to work with the important stakeholders to ensure that DME processes and procedures are transparent to the students and their families, local communities, state, and federal level education officials so that everyone can work together to improve racial equity.

Methods and Results

Institutional data from Fall 2012 to Spring 2023 were collected, examined, trend-analyzed and summarized to collect DME students' baseline rates such as pass, fail and withdrawal rates. Studying the trends of baseline

success and failure rates of these "underprepared" students provide a condensed report to the institutional and state-level stakeholders which will hopefully provide more research-based and data-driven strategies and interventions to improve these students' degree completion rates. Figures 1 and 2 describe the Fall Semesters Grade Distribution for MATH 1113 (Fundamentals of Algebra) and MATH 1123 (Transition to College Math), respectively.

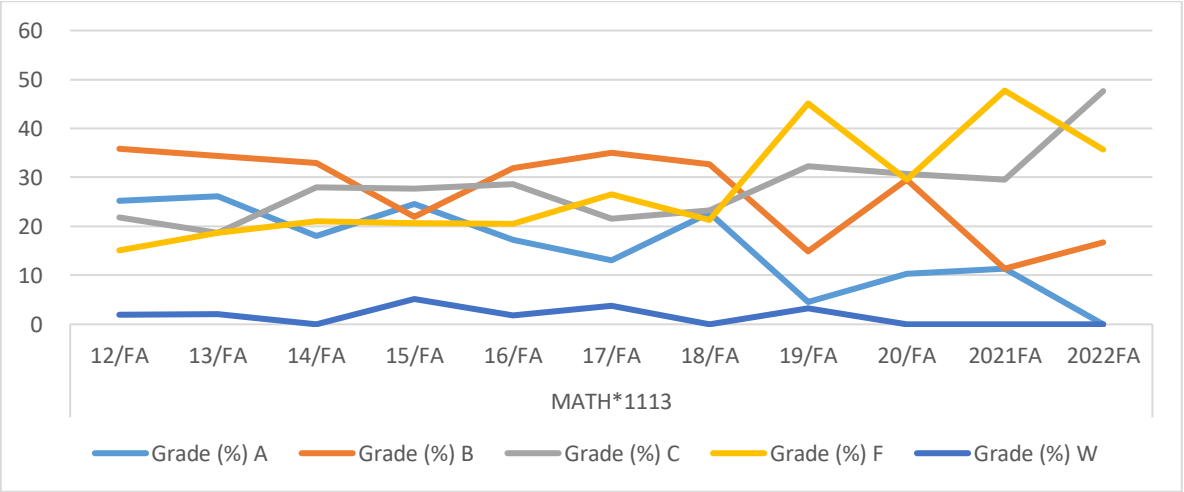

Figure 1. Fall Semesters Grade Distribution for MATH 1113 (Fundamentals to Algebra)

Figure 1 shows the withdrawal rate for MATH 1113 for fall semesters has been staying below 10 percent for the whole decade; see light blue line graph. Grades A, B, and C (blue, orange, and gray) have stayed within 10 to 40 percent from years 2012 to 2018. The percentage range for A, B, and C widened in years 2019 to 2022 from 0 to 50%. Figure 1 also describes a downtrend of percentages of students achieving grades A and B and an uptrend of percentage of students passing the course with a C in this latest three-year period The yellow line graph shows higher percentage of students failing (F) for years 2019-2022.

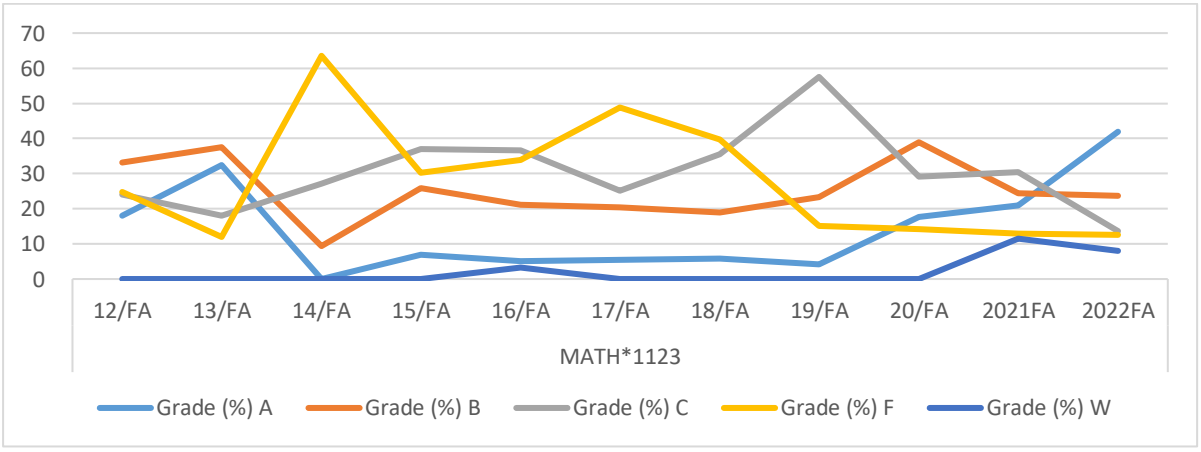

Figure 2. Fall Semesters Grade Distribution for MATH 1123 (Transition to College Mathematics)

Figure 2 shows the withdrawal rate for MATH 1123 (Fall semesters) has been staying below 12 percent for the whole decade. Like MATH 1113's trend, percentages of students obtaining grades A, B, and C have stayed within

0 to 40 percent from years 2012 to 2018. There is a large increase of percentage of students obtaining C in 2019 and tails off in 2020-2022. There is an uptrend of percentage of students achieving A from 2019 to 2022. The withdrawal rate shown by the yellow line trends down ever so slightly for 2019-2022. Now, are these percentages we see for fall semesters mirrored by the spring semesters' percentages? Figures 3 and 4 describes the trends of the percentages of students' achievements. Figure 3 shows that percentages of students achieving A, B, and C are within 0 to 60 percent. The two spring semesters of 2015 and 2022 have high failure rates which are 40 and 60 percent, respectively. One obvious explanation for the Spring 2020 was COVID-19.

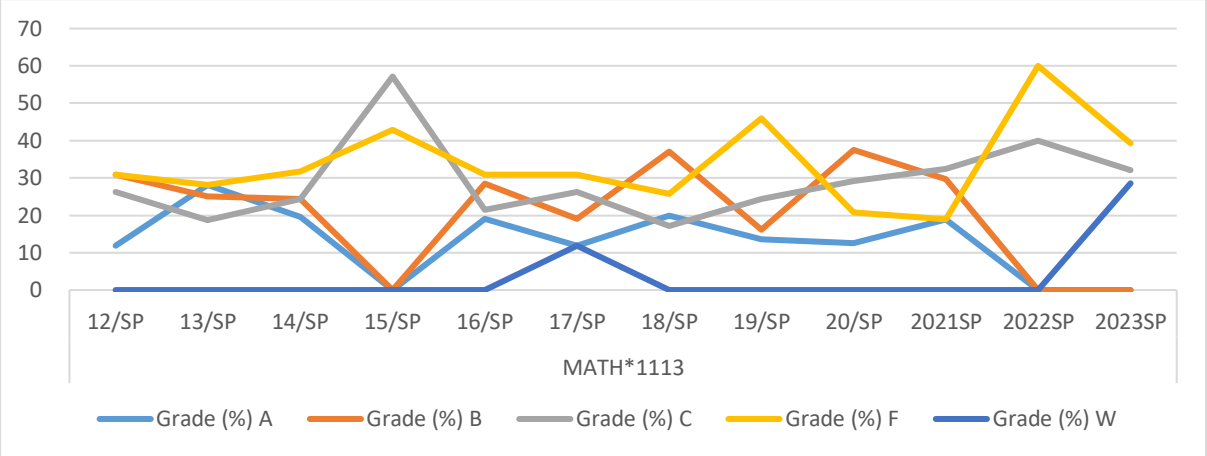

Figure 3. Spring Semesters Grade Distribution for MATH 1113 (Fundamentals to Algebra)

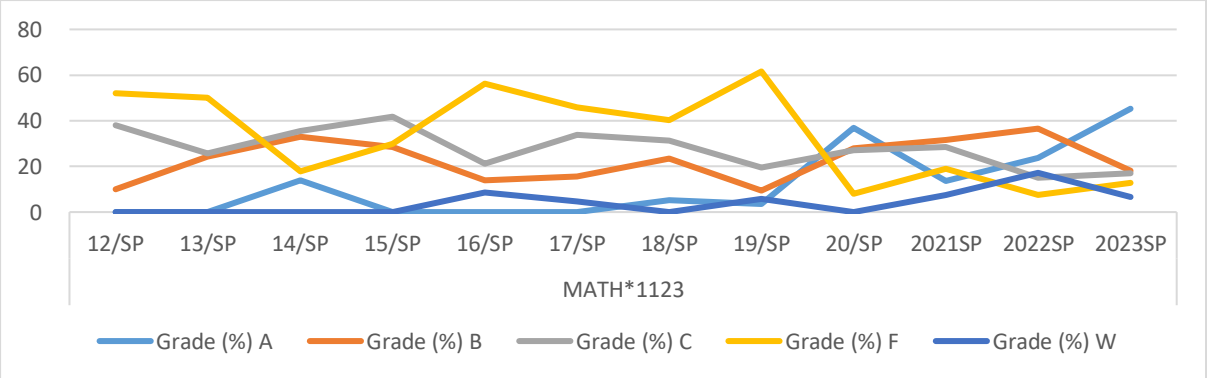

Figure 4. Spring Semesters Grade Distribution MATH 1123 (Transition to College Mathematics)

Figure 4 shows percentages of students obtaining A, B, and C are within 0 to 45%. There is an uptrend of students' percentage obtaining A for Spring 2021-2023. Failure rates dropped from 60 percent to between 8 and19 percent in Spring 2020-2023.

Discussion

Once these students are admitted and registered for the DME classes at TWU, the University is accountable for their forward and upward educational progress. Hence, it is also imperative that important baseline rates such as pass, fail and withdrawal rates be determined and reported.

For AY 2012-2019, TWU has been using the traditional DME teaching learning model. Students were classified and placed in either MATH 1113 or MATH 1123. In Spring 2020, there was an initial implementation at TWU of this corequisite model at TWU. One MATH 1123 section students (out of four sections) must enroll simultaneously in MATH 1013. MATH 1113 were not affected by this corequisite model. Starting Fall 2020, the corequisite model was implemented across all five sections of MATH 1123 where three sections of MATH 1123 must enroll in MATH 1703 (Elementary Statistics I) and two sections of MATH 1123 must enroll in MATH 1013 simultaneously. Table 2 summarizes what has been done at TWU addressing the corequisite model mandated by the Texas Legislation HB 2223., https://capitol.texas.gov/tlodocs/85r/billtext/html/hb02223i.htm

Table 2. Corequisite Implementation at TWU (Spring 2020 – Spring 2023)

SEMESTER / Corequisite Model	MATH 1123/1013	MATH 1123/1703	MATH 1123/1303
Spring 2020	1 section out of 4 sections	0	0
Fall 2020	2 out of 5	3 out of 5	0
Spring 2021	2 out of 4	2 out of 4	0
Fall 2021	2 out of 6	3 out of 6	1 out of 6
Spring 2022	1 out of 4	2 out of 4	1 out of 4
Fall 2022	2 out of 7	4 out of 7	1 out of 7
Spring 2023	1 out of 5	3 out of 5	1 out of 5

Does the Corequisite Model improve the success rates of DME students in MATH 1123?

Mullins (2018), Logue et al (2018), and Guillory (2021) determined and reported that the "corequisite math study skills course did NOT have an impact on any of the college outcome variables (grade point average, transferability, and completion) and was deemed statistically insignificant". Zooming in on the semesters when corequisite model was implemented, Table 3 describes the frequencies of students' grades for MATH 1123 when enrolled simultaneously with MATH 1013, 1703, 1303.

Figures 2 and 4 contain the data set which includes the baseline rates of these DME students with corequisite model implemented. To further discuss the details, two tables, Tables 3a and 3b, describe the Grade Distribution (frequencies) of MATH 1113 AND MATH 1123 for Spring 2020 to Spring 2023 semesters, respectively.

Table 3a. Grade Distribution of MATH 1113 Students (#, Spring 2020-Spring 2023)

Term		Grade (#)				
		A	B	C	F	W
MATH 1113	20/SP	6	18	14	10	*
	20/FA	8	23	24	23	*
	2021SP	7	11	12	7	*
	2021FA	5	5	13	21	*
	2022SP	*	*	10	15	*
	2022FA	*	7	20	15	*
	2023SP	*	*	9	11	8

Note: Frequencies less than 5 are masked with *.

Table 3b. Grade Distribution of MATH 1123 Students (#, Spring 2020-Spring 2023)

Term		Grade (#)				
		A	B	C	F	W
MATH 1123	2020SP	37	28	27	8	*
	2020FA	20	44	33	16	*
	2021SP	13	30	27	18	7
	2021FA	31	36	45	19	17
	2022SP	22	34	14	7	16
	2022FA	83	47	27	25	16
	2023SP	67	27	25	19	10

Note: Frequencies less than 5 are masked with *.

Table 3a describes the grade distribution of DME students' grades for the traditional model while Table 3b shows the grade distribution of DME students' grades for the corequisite model. Figures 5 and 6 provide a more compact and easier way to compare the effectiveness of the traditional and corequisite DME models.

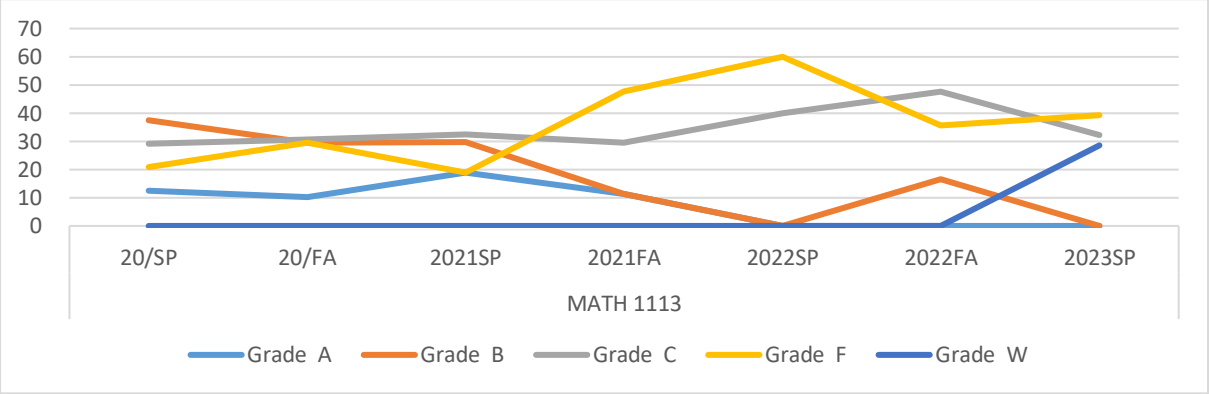

Figure 5. Grade Distribution (%) for Traditional DME Model (Spring 2020-Spring 2023)

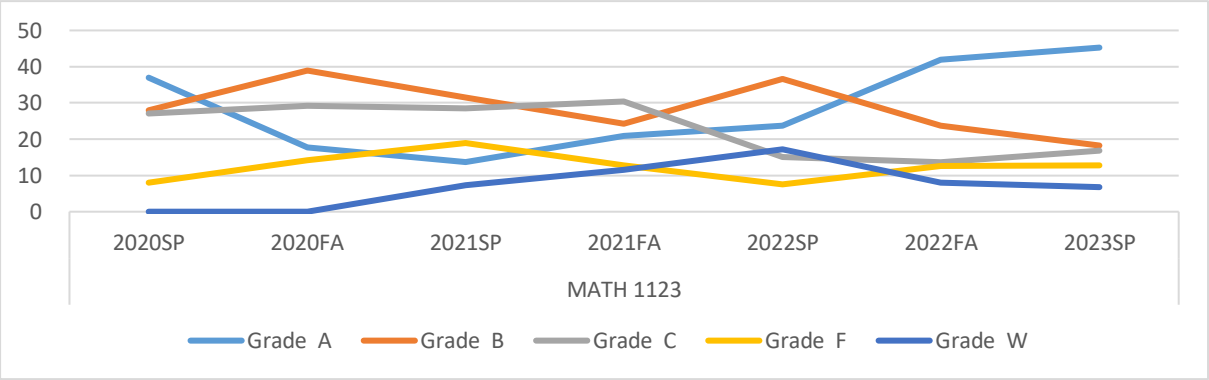

Figure 6. Grade Distribution (%) for Corequisite DME Model (Spring 2020-Spring 2023)

Figure 5 indicates that there are more MATH 1113 students failing and withdrawing in Fall 2021 to Spring 2023 while Figure 6 shows higher percentages of students obtaining pass rates, with grades A, B, and C. This means

that these MATH 1123 students have automatically received college-level mathematics credits. It is important to note that the result explained above is the opposite result of the claim of Mullins (2018) and Guillory (2021) and agrees with the results of Logue et al (2018). A large percentage of DME students completed the corequisite courses and were awarded mathematics college credits towards their degree requirements.

Why Look Through the Lenses of Justice, Equity, Diversity, and Inclusion (JEDI)?

Racial and ethnic inequities are generic and familiar issues in education, especially in mathematics education. One paper by D. Martin (2009) reviewed and analyzed how the construct of race / ethnicity has been conceptualized in mathematics education research, policy, and practice. Examining racialized inequalities by considering the socially constructed nature of race and ethnicity would improve the mathematics education research and policy at the individual-, societal-, institutional-, state-, and national- levels. Denaro et al (2022) identified systemic inequity in higher education and provided a list of future reforms that can leverage useful and research-based beneficial practices at the levels of instruction and fields of study, in this case, STEM fields. This paper mentioned that "persons excluded because of their ethnicity or race" (PEERs) have been experiencing lower baseline completion rates in STEM programs. Six years of institutional data from a large research minority serving institution were collected and analyzed to examine the racial opportunity gaps between PEERS and non-PEERS; found that the racial opportunity gaps are more pervasive in lower division curriculum across all STEM disciplines. Bollyky et all (2023) assessed COVID-19 pandemic policies and behaviors and the corresponding state-by-state educational and economic trade-offs and found that COVID-19 intensified the pervasive economic, societal, and racial inequities across all states in the US. The lesson learned is that the next pandemic should not have the same effect. Vithal et al (2023) reported that there is an increase in focus on equity in mathematics education as well as improvement of broader diversity research studies in this area and concluded that the Global North has been more influential in shaping the conversations on equity-related issues while there is a low level of research output on JEDI research studies from the Global South.

Focusing on JEDI Issues at TWU

What is important to notice is that Texas Woman's University (TWU) is the largest university in the United States of America focused on women. It is also classified as a Hispanic Serving Institution (HSI). This new demographic composition of TWU renders this report highly necessary and important. This means that TWU has done research-based interventions that resulted to the upward movement of most of these DME students towards degree completion. Refer to Wakefield, (2020) and Boatman, (2021). Additionally, a well-planned set of procedures for placing these students in the correct remediation courses brought about these positive changes. DME students who are supposed to take Elementary Statistics as part of their degree program have been advised and placed in MATH 1123 and the percentages of passing rates have indeed improved. See Alkhateeb (2022), Merkin (2023), and Petillo & Anuszkiewicz (2023). Similarly, DME students who are supposed to take quantitative and financial literacy as part of the degree requirements have benefited from this corequisite model. Many students who are placed in developmental mathematics courses are low-income and students of color. These students lack the necessary resources to help them persist through a sequence of remedial mathematics classes. The corequisite

model implemented at TWU since Spring 2020 has the additional academic support embedded with it. The students are provided supplemental instruction as well as additional tutoring sessions. This made a vast and massive difference to the DME students in MATH 1123 as shown by the much-improved course completion rates. DME students in MATH 1113 did not receive supplemental instruction and this may be the reason why there are higher withdrawal and failure rates. TWU is one of the higher educational institutions moving towards maximizing students' success in developmental mathematics classes and improving the interactions between students' social and physical environments (Kiser, 2016, Ladson-Billings, 2021, Pena et al, 2021, Childers et al, 2021).

Research-Based and Equity-Minded Practices State-Level Implications

One excellent future research study worth pursuing will be based on the state-by-state developmental education mandates. Based on the work done by Hodges et al (2021), a concatenated table from the paper is shown as Table 4.

Table 4. Concatenated Table from Hodges et al (2021) showing 4 Red States and 4 Blue States based on the 2020 Election Results

State (electoral college votes)	Does State Wide or System Wide Policy Address DE?	Does State Wide or System Wide Policy Address DE Assessment?	Does State Wide or System Wide Policy Address DE Placement?	Does State Wide or system Wide Policy Address DE Instruction Reform?	Does State Wide or System Wide Policy Address Advising for Students in DE?
Texas (38)	Y	Y	Y	Y	Y
Florida (29)	Y	Y	Y	Y	Y
Ohio (18)	Y	Y	Y	Y	N
North Carolina (15)	Y	Y	Y	Y	N
California (55)	Y	Y	Y	Y	Y
Washington (12)	Y	Y	Y	N	N
Illinois (20)	Y	Y	Y	Y	N
New York (29)	Y	Y	Y	Y	Y

Table 4 shows the answers of 4 blue states and 4 red states to a 5-question checklist. Hodges et al (2021) noted on page 3 that the "lack of policy did not necessarily signify lack of assessment." Furthermore, additional data-driven research studies are needed to investigate the effect of the big picture snapshot shown in Table 4. In two to three years, implications of these state-level policies would be studied and analyzed.

Acknowledgements

The author would like to thank TWU's Office of Academic Assessment Fellowship and Support.

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