
Efforts to Improve Mathematical Preparation for a Pre-Engineering Program at Tribal Colleges in North Dakota

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Abstract

Developmental math preparation is integral in a pre-engineering pathway. This paper analyzes the efforts to improve remedial math passing rates at two tribal colleges in North Dakota participating in a pre-engineering collaborative. Previous work in progress addressed portions of these approaches, but here a more complete set of quantitative data is presented along with further analysis using the theoretical framework of Tribal Critical Race Theory.

Introduction/Context

Math progression rates out of remedial math courses is low. This is a nation-wide concern as data shows that 80% of students in developmental (used synonymously with remedial) math courses do not complete any college-level mathematics course within three years [1]. This situation is not conducive to a pre-engineering pathway at a tribal college where a majority of students are placed into these courses. Is there an approach to teaching developmental math that will increase the number of students that succeed in remedial math and move on to higher math course levels? As a variety of steps are taken to this end, the obvious question is: ‘Did it work?’

This paper looks at the math education programs at two tribal colleges/universities (TCUs) contributing to a statewide pre-engineering program. The original construct of the program was that students could take some or all of their first-year courses, including mathematics, at a TCU before participating in the specialized engineering curriculum at North Dakota State University. Each TCU implements personalized student attention with cultural relevance to overcome barriers in, not to, higher education for Native American students. Cankdeska Cikana Community College (CCCC) has been serving students of the Spirit Lake Tribe since 1975. A few years earlier, Turtle Mountain Community College (TMCC) began serving their students through the 1972 charter by the Turtle Mountain Chippewa Tribe.

Similar to colleges and universities across the country, CCCC and TMCC are pursuing remedial math curriculum approaches to best serve their students. In 2017, both institutions began participating in Achieving the Dream, a foundation-supported effort of 277 colleges aiming to increase graduation rates of students. Nationally, no statistics exist to track remedial math pass rates, but within the Achieving the Dream network remedial math pass rates are lower than desired across the board [2]. Our previous paper [3] addresses in detail the new approaches that CCCC is pursuing and will be further discussed in the Results section.

Originally, four TCUs in North Dakota were participating in this analysis. But all of us have experienced the COVID-19 pandemic causing an upheaval in every portion of our lives at some level or another. Due to this, two of the four original participating institutions were not able to easily retrieve the data and therefore their data is no longer included in this paper as the accepted abstract states. Yet, this lost contribution still tells us of the changing landscape to higher education that we are all experiencing currently and will continue to experience throughout the aftermath of this pandemic.

Theoretical Framework and Methodology

Theoretical frameworks are essential to the discipline-based education research community. It gives the axioms and lens to discuss and analyze within the social sciences. For scientists, the ‘gold standard’ is the double-blind test, two identical populations, experiencing intentionally different situations to determine the impact of that difference on intended outcomes. In some situations that is relatively easy, i.e. testing the effect of tire pressure on the handling of a car, but with people, and specifically with particular populations, that is not easily done. Case in point, two populations of students at different tribal colleges, from different Nations, surrounded by different community norms, each experiencing ‘a different approach’ to remedial math.

Nothing happens in a void. That is, every aspect of the math and pre-engineering experience happens within a socio-cultural context including classmates, instructors, college, family, community, and nation. Our value system, how we perceive reality around us, how we define knowledge, and what knowledge we prioritize all stem from our socio-cultural context [4]. From this point of view, we chose a theoretical framework stemming from Critical Race Theory. Tribal Critical Race Theory posits nine tenets. First, ‘colonization is endemic to society.’ Directly speaking to education, ‘government and education policies toward Indigenous peoples are intimately linked around the problematic goal of assimilation.’ Lastly, ‘tribal philosophies, beliefs, customs, and visions for the future are central to understanding the lived realities of Indigenous peoples as well as illustrating the differences among individuals and groups [5].

The situation being described in this paper is not a double-blind context leading to a ‘silver bullet’ discovery or confirmation. Uncontrollable variables surrounding the two cases are too numerous to allow enough isolation to provide an extrapolation toward such a generalized ‘answer’. To not additionally disturb, this study describes some of the situations the populations are experiencing and outcomes. A standardized pre/post-test was abandoned due lack of availability of a test designed for this population without bias. Populations are too small and without enough control to allow derivation of a statistically significant outcome and definitive recommendations. Rather, the situations and their contexts are explored to provide insights as to spectra of outcomes, confirming that no significant ‘damage’ was inflicted and that positive outcomes were witnessed. Discussion of those outcomes will focus upon aspects that have the potential to lead to more substantial and verifiable results or initiate more significant questions.

Results

Turtle Mountain Community College (TMCC) has maintained a traditional approach to remedial mathematics while the other tribal colleges have investigated alternative methods. The college has continued to employ a traditional format because consistency in the educational pathway has allowed students the best opportunity to be successful at the college. Students enroll knowing what to expect from each math course and the required learning objectives. This enhances student comfort with the pathway and eliminates any anxiety that may occur due to uncertainty within the math curriculum. The remedial math courses offered at TMCC consist of MATH 100 – Applied Mathematics and MATH 102 – Intermediate Algebra. These courses are designed and instructed in a manner that adequately prepares the students for the first college-level course in the math pathway, MATH 103 – College Algebra.

The TMCC remedial math (MATH 100 and MATH 102) pass rates are shown in Figure 1 below. The chart compares the pass/fail rates and the percentage of students who advanced onto higher level math courses after taking a remedial class. The total number of students over the 3 semesters are given next to each year. The data shows the pass rates tend to be higher in the spring and summer semesters compared to the fall. Typically, this is due to students who retake the class feeling more comfortable with the material and being able to successfully complete the course on a second attempt. The percentage of students progressing onto advanced courses were relatively constant for the fall and spring semesters. Overall, the pass rate percentage for remedial math students showed improvement over the 5-year period while starting at 55% in 2014 and reaching a maximum of 82% in 2017. The percentage of students advancing remained relatively constant at around 48% over the five years.

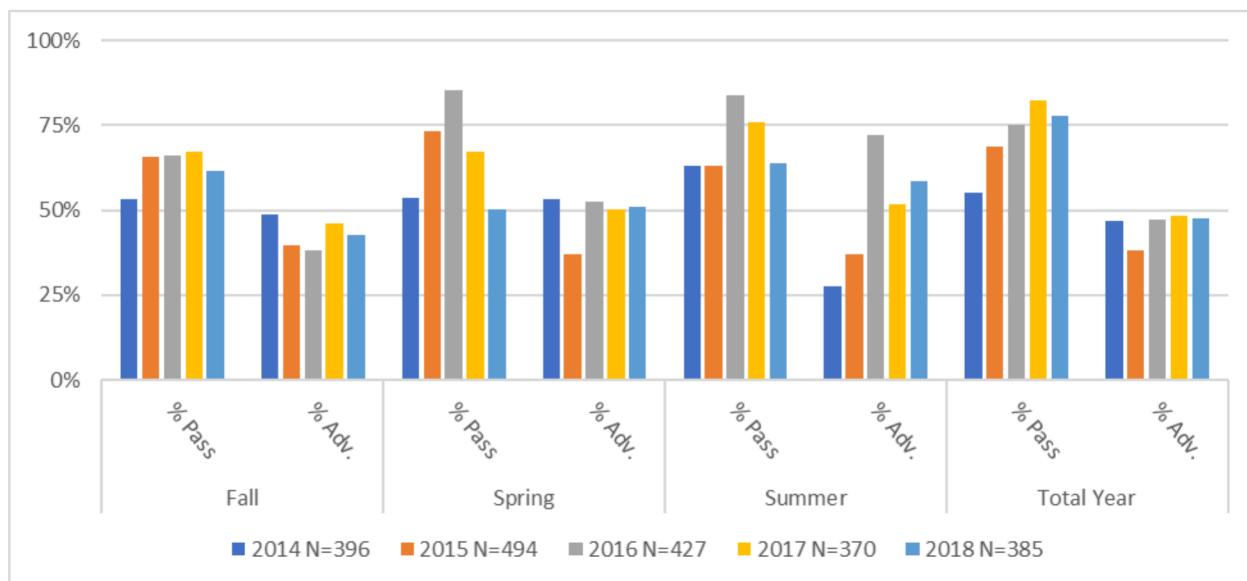


Figure 1: TMCC Remedial Pass Rates and Percentage Advancing to Higher Level Courses

Cankdeska Cikana Community College (CCCC) for its remedial math courses has implemented Hawkes, an online mastery learning software. The students work through a 'Study, Practice, Certify' progression utilizing an online textbook with interactive problems, online tutoring videos, and step-by-step instruction on any particular problem. Although the Hawkes system has the potential to run without any live instructor, CCCC has included regularly scheduled class periods with instructors and peer tutors for face-to-face interaction. Yet because of its stand-alone delivery capabilities, students are able to make up the learning from any absences and have autonomy to move at their own pace which were both missing in their previous lecture format.

The CCCC remedial math pass rates are shown in Figure 2 below. The chart compares the pass/fail rates of intermediate algebra and the percentage of students who advanced onto college algebra, the first math course counting for college credit. Summer semester data was omitted from the bar graph, but not the total year data, because of summer class size ranged from one to four students during the past six years. The pass rates show improvement in the spring semester compared to the fall. Overall, the advancement rate to college algebra for intermediate algebra students showed improvement over the 6-year period while starting at 14% in 2014 and reaching a maximum of 56% in 2019.

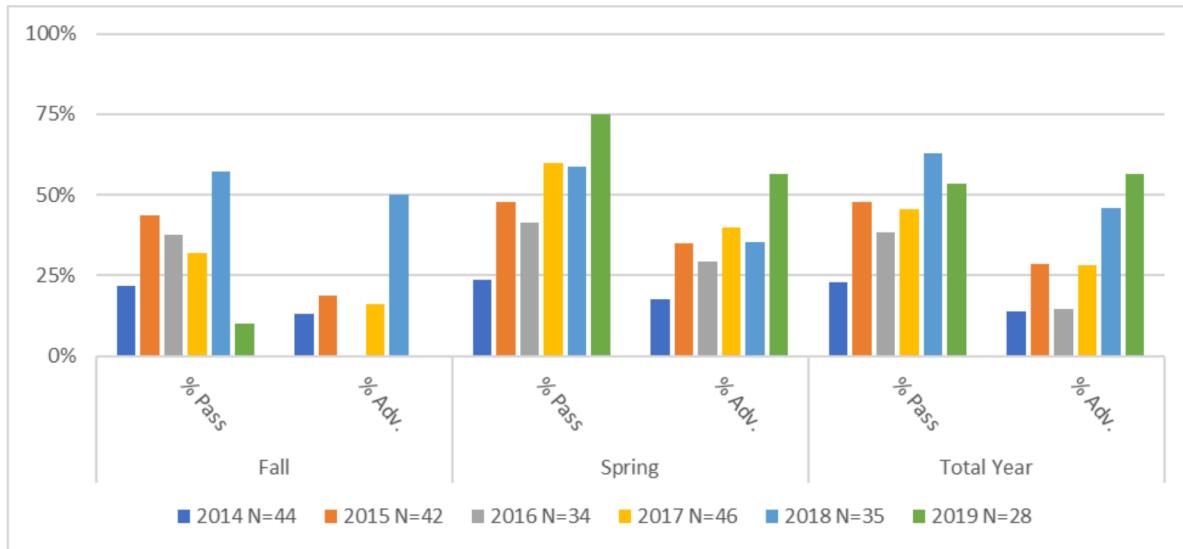


Figure 2: CCCC Int. Algebra Pass Rates and Percentage Advancing to College Algebra

Due to COVID-19 constraints, when comparing CCCC and TMCC, it is necessary to note that the TMCC data looks at all developmental math courses while CCCC looks only at the last developmental course before college algebra. Dissimilar sample sizes also follow from TMCC having approximately three times the student body as CCCC. However, both institutions show dramatic improvement being experienced as the administration and faculty continually seek the best opportunities for their students. The factors of this significant improvement however are very difficult to precisely pinpoint. Hawkes learning system was implemented fall of 2013 and is likely part of the improvement at CCCC but data before that change isn't available.

As Tribal Critical Race Theory guides our further analysis, the variances in the two institutions approaches, student enrollment, and pass rates demonstrates that the students, community, and tribal colleges are not the same. In some research, all Native American students are aggregated into one category. Yet we readily observe here that the socio-culture context is unique to each Nation, reservation, and tribal college. This is a valuable observation for future research and aligns to the tenet stating that tribal philosophies, beliefs, customs, traditions, and visions for the future are central to understanding the differences among individuals and tribal nations [5].

Turtle Mountain Community College:

Unique to TMCC, two college algebra paths have been attempted and evaluated. College Algebra (C.A.) is a traditional one semester course whereas College Algebra I (C.A. 1) and College Algebra II (C.A. 2) cover the same content as C.A. over two semesters. Figure 3 below compares the pass rates for each semester over a five-year period. The pass rates show improvement in the spring semester compared to the fall. In the spring of 2018, faculty noted that students who did not pass C.A. 1 or C.A. 2 in the first attempt were a year behind those who passed the traditional C.A. class so TMCC switched to offering only C.A. in the future. This is noted in the results where C.A. tended to have higher pass rates than C.A. 1 and C.A. 2 and averaged around 80% until dropping to 50% in 2018. The college added supplemental tutoring options and updated its math placement test to aid students who were affected by the switch.

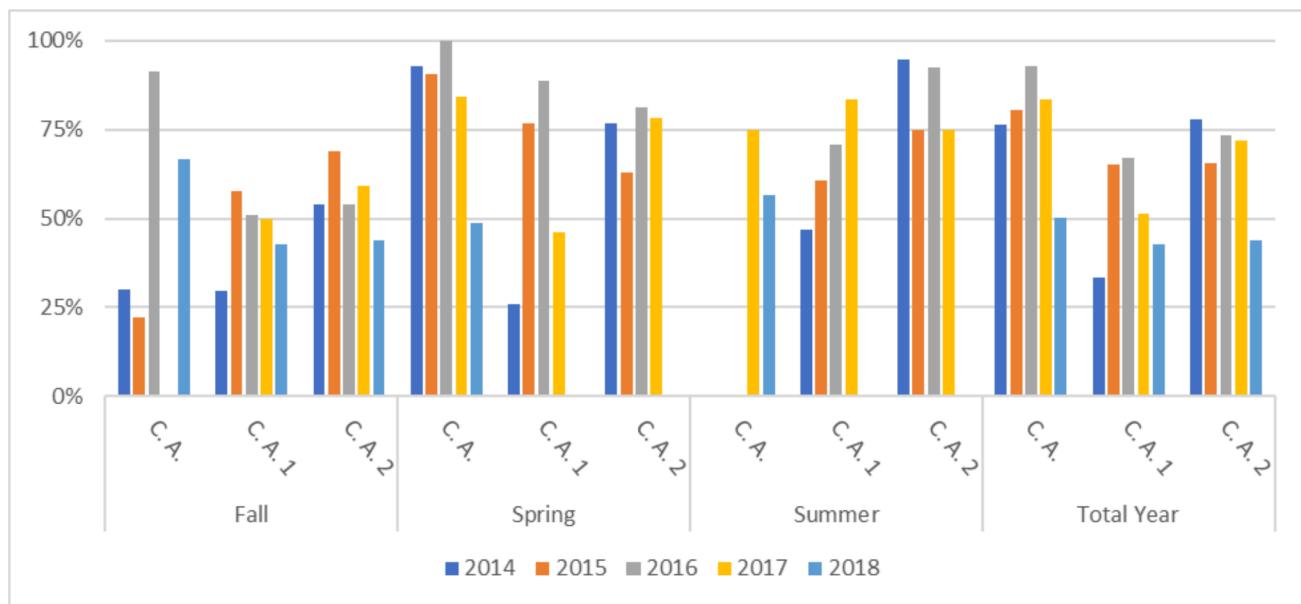


Figure 3: TMCC College Algebra Pass Rates Compared to College Algebra I and II.

Cankdeska Cikana Community College:

More fully described in our previous paper [3], CCCC has implemented Carnegie Math Pathways as an alternative developmental course sequence that shortens the traditional algebra sequence. Carnegie has developed this evidence-based curriculum [6] in two strands, Statway and Quantway, both of which seek to make mathematics more relevant to students' education goals, career goals, and personal lives. Figure 4 below shows the three semesters of Quantway Core meant to replace the year sequence of Introduction to Algebra and Intermediate Algebra.

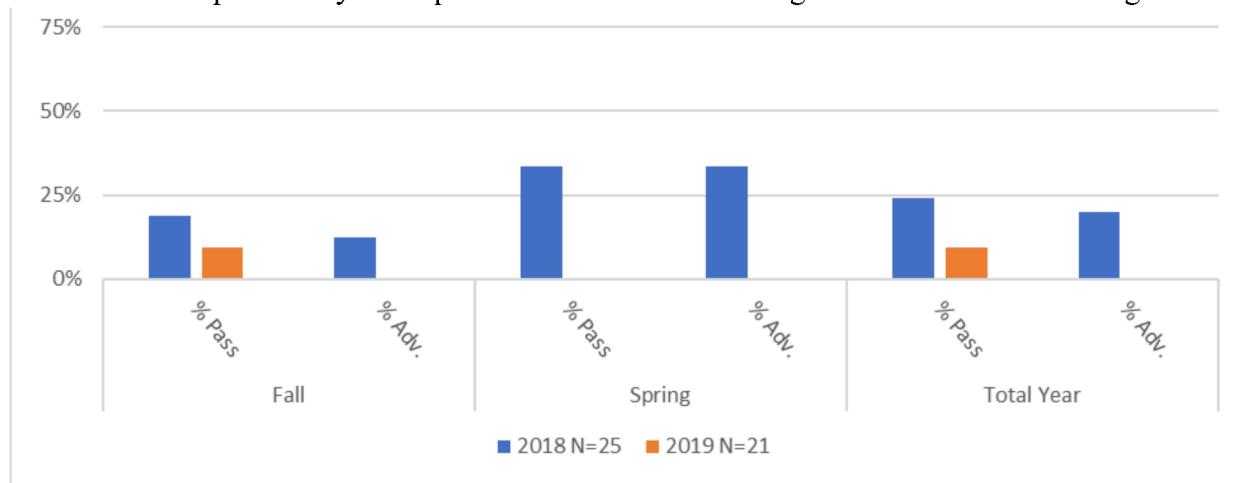


Figure 4: CCCC Carnegie Quantway Pass Rates

Results from Carnegie Quantway have been discouraging. A well-funded, research-based [6], curricula approach has not adequately served the students at CCCC. There could be various reasons for such results. Lack of proper implementation was dismissed by the faculty as they attempted to follow Carnegie's instructor guidance wholly. Additionally, these same instructors implemented Carnegie Statway in spring 2019 in place of Elementary Statistics and 10 of 14

(71%) passed. This comes after spring 2018 Elementary Statistics had 2 of 8 (25%) pass, showing Statway to be very promising. Both Quantway and Statway were developed by Carnegie with diverging results, albeit small sample size. Faculty did anecdotally observe a difference in motivation, college-readiness, and year in college amongst the Statway students.

Against discipline-based education research current belief, some faculty seem to believe that these curriculum approaches are not the key to student success and pass rates but rather anecdotally observing that the strength of the student-instructor relationship to be the largest factor with their students. Faculty, willing to push against mainstream research emphasizing curriculum and assessment following certain validity measures, offer an alternative emphasis in relationship building to best serve students in context at CCCC. This aligns with Tribal Critical Race Theory tenet one stating colonization is endemic to society by showing how assimilated most research and education are [5]; a ‘new’ approach is offered based upon relationship.

Summary

TMCC and CCCC have both significantly increased their pass rates in remedial math courses in the past five years, thus further opening the door for the pre-engineering program. Each TCU is implementing their own unique approach demonstrating one size does not fit all. When looking at increasing the number of successful students in remedial math, we must look at context, that is the relationships between student, tribal college, community, family, and Nation. By doing such, TMCC and CCCC are seeing improvements. Through analogy to the COVID-19 pandemic, where different portions of our country are affected at varying rates and different occupations within our society are affected in different ways, so too, no universal ‘silver bullet’ for remedial math is shown by our data but rather our decisions need to be made in a fuller context.

Further work seeks to share the data and analysis from two other TCUs in North Dakota that were halted by the COVID-19 pandemic. Also, a deeper dive into relationship and context-dependent pedagogies is appropriate which may perhaps intersect with culturally responsive and sustaining pedagogy.

References

- [1] T. Bailey, D. W. Jeong, and S.-W. Cho, “Referral, enrollment, and completion in developmental education sequences in community colleges,” *Econ. Educ. Rev.*, vol. 29, no. 2, pp. 255–270, Apr. 2010, doi: 10.1016/j.econedurev.2009.09.002.
- [2] D. E. Blum, “Getting Students Through Remedial Math Is a Constant Struggle, but This College Keeps Trying,” p. 4.
- [3] M. M. M. Parker *et al.*, “Work in Progress: Alternative Developmental Math Curriculum Designed to Accelerate the Sequential Coursework by Implementing Quantitative Reasoning,” p. 8 2019.
- [4] M. Walter, “Indigenous Statistics: Doing Numbers Our Way,” p. 23, 2016.
- [5] B. M. J. Brayboy, “Toward a Tribal Critical Race Theory in Education,” *Urban Rev.*, vol. 37, no. 5, pp. 425–446, Dec. 2005, doi: 10.1007/s11256-005-0018-y.
- [6] M. Huang, *2016-2017 Impact Report: Six Years of Results from the Carnegie Math Pathways™. Carnegie Math Pathways Technical Report*. Carnegie Foundation for the Advancement of Teaching, 2018.