Work in Progress: Alternative Developmental Math Curriculum Designed to Accelerate the Sequential Coursework by Implementing Quantitative Reasoning

Mr. Michael Maloy Parker, Cankdeska Cikana Community College

Mike Parker received a BS in Mechanical Engineering from North Dakota State University. He served in the US Army as a reliability engineer and vehicle test officer. He has been an agricultural producer in his home state of ND as well as being involved in local manufacturing and oil well hydraulic fracturing. He is currently an instructor at Cankdeska Cikana Community College in the Pre-engineering program.

Mrs. Lori Nelson, Nueta Hidatsa Sahnish College

Lori Nelson began her professional experience as an Industrial Engineer working the capacity of business process manager for a major U.S. aerospace manufacturing firm. This role provided functional consulting for supply chain with key ownership responsibility ensuring appropriate data design of master data, IT architecture and solution design for all ERP solutions across the organization.

She holds a Masters of Arts in Teaching Mathematics from Minot State University, a Bachelor of Science degree in Industrial Engineering and Management from North Dakota State University, and post-masters certificate in Experiential Education through Equine Assisted Learning from Prescott College.

Currently she serves as the Land Grant Director and also as PI of the Pre-Engineering Education Collaboration (PEEC) Grant at Nueta Hidatsa Sahnish College in New Town, ND. In addition, she teaches Mathematics and Equine Studies courses.

Her and her husband, Chris, live and raise Angus beef cattle, near Towner, ND. In her spare time, she enjoys riding horses and providing community outreach through relational horsemanship through the Nueta Hidatsa Sahnish College Horse Nation program. Currently she serves on the board of directors for an engineering firm that specializes in transportation engineering and materials testing.

Dr. Robert V. Pieri, North Dakota State University

Dr. Robert Pieri is Professor of Mechanical Engineering at North Dakota State University (NDSU) in Fargo, ND. He has many conference publications on engineering education and design. His primary interest areas include: Engineering Education, CADD, Design, Fracture Mechanics, Materials Science and Alternative Energy Options. Prior to joining NDSU, he worked for Allied-Signal Corporation and in the aircraft supply industry. Prior to his industrial experience he taught for 10 years at the US Air Force Academy. Prior to his time at USAFA, Bob was a Research & Development Engineer with the US Air Force, studying problems of pollution in the earth's atmosphere. One of his dissertations involves the environment and policy decisions that could affect it. Dr. Pieri has degrees from the University of Massachusetts at Amherst, Thayer School at Dartmouth College and Carnegie – Mellon University in Pittsburg, Pennsylvania. For the academic year 2003- 2004, Bob was on the faculty at Turtle Mountain Community College in Belcourt,N.D. where he taught Math and Engineering classes. This is the basis for his current interest in Native Americans into Engineering. Bob, originally from the northeast area of the USA, has been a resident of Fargo, ND since 1996.

Dr. Austin James Allard, Turtle Mountain Community College

Austin Allard is a Pre-Engineering Instructor at Turtle Mountain Community College. He earned a doctorate degree in Civil Engineering from Texas A&M University. His work deals with using manufactured drones to map ecological areas. He is dedicated to using engineering solutions to investigate environmental issues close to home.

Ann Vallie
Dr. Josh Mattes, Sitting Bull College

Dr. Josh Mattes grew up in Indiana. He received his PhD in Physics from Purdue in 2013. His research interests are foundations of quantum mechanics, finite temperature quantum field theory, and STEM education.

Teri Ann Allery
Mr. Karl Haefner, Cankdeska Cikana Community College

Cankdeska Cikana Community College Karl Haefner, PEEC Collaborative Team Member. University of Phoenix, M.A.e.d., Secondary Education, 2008 Grand Valley State University, B.S. Geology, 2004 Saginaw Valley State University, B.S. Mechanical Engineering, 1988 Mr. Haefner is an engineering instructor at Cankdeska Cikana Community College, where he is actively working to build the Pre-Engineering Department. He assisted with writing the AMI accreditation report to the HLC, wrote several successful grants, and managed CCCC's Advanced Manufacturing Curriculum and Pre-Engineering Educational Consortium. In addition the Advanced Manufacturing initiative at CCCC has hired two undergraduates to run the 3-D/Scanner Laboratory. The aforementioned gives the students hands on training in a STEM related field. Mr. Haefner has 13 years' experience teaching college STEM courses. He has taught construction management at Westwood College in Chicago; mathematics at Mid-Michigan Community College and Cornerstone University in Grand Rapids, MI. Mr. Haefner has taught algebra, engineering statics, several HVAC courses, several CMT classes, as well as AutoCAD and Advanced Manufacturing using SolidWorks. Mr. Haefner also has over 15 years; experience in the fields of civil, geo-technical and environmental engineering at companies including: Testing Service Corporation in Carol Stream, IL; Singh & Associates in Chicago, IL, Weaver, Boos and Gordon in Chicago, IL; STS Ltd. In Grand Rapids, MI.

Alternative developmental math curriculum designed to accelerate the sequential course work by implementing statistical and quantitative and reasoning concepts (Work in Progress).

ABSTRACT:

The alternative developmental math curriculum offered at two North DakotaTribally Controlled Colleges using a modified pedagogical delivery system offers sound mathematical principals based on life-skills with relevant problem-solving, while explicitly addressing other holistic needs of the student such as math anxiety, persistence, mindset, and the value of collaboration (group work). This cooperative work is intended to create a community of learning which is in tune with traditional Native American cultural practices. Students learn to be responsible for their learning, engage in teamwork, and develop an assenting attitude towards mathematics.

CONTEXT:

A situation that is a common challenge for secondary institutions is the lack of preparedness in the area of math for their incoming students. As a result, the student places into developmental math (remedial math) and has the following scenario:

ASC 091- Pre-Algebra (arithmetic) >> ASC 092- Introduction to Algebra >>
ASC 093- Intermediate Algebra >> Math 103- College Algebra

Since each of the above is a semester in length, one can readily observe that there is a time issue with regards to completion, which is especially significant at two-year institutions. Also, the credits earned in the three developmental courses do not count towards a statewide general math education and neither are they included in a typical engineering curriculum or for that matter for most Program of Studies for other possible degree alternatives. This, in turn, causes students to either have to increase their credits/semester in order to finish their program of study in two years or add at least one additional semester of coursework. Because of this delay in advancement, or achievement in course progress, several other consequences may manifest in the student such as a lack of persistence due to malaise, or a seeming confirmation of the general perception that engineering students have to have an innate initial propensity in mathematics versus an ability that is learned.

For these reasons, many students who did not fare well in the traditional high school level math sequence, attempting to try a similar path in college may be setting themselves up for a repeat conclusion. According to Snyder and Dillow (2011), more than 1.7 million students enter the community college system. Based primarily upon performance on a placement test, approximately 60% of these students are placed into one, if not more, developmental mathematics course(s). Fully 80% of them do not

complete any college-level mathematics courses within as many as three years (Bailey, Jeong, & Cho, 2010).

At our North Dakota Tribally Controlled Colleges, we see similar results with 80% of students placing into a developmental math sequence. This situation is not conducive to the development of actively occupied engineering pathways from TCC's to mainstream institutions as supported through the NSF Pre-Engineering Education Collaboratives (PEEC). A multi-semester delay in transitioning from the TCC to the mainstream institution can invoke an increased risk factor for the students in the program. Steps needed to be taken to accelerate the progression of PEEC students through the program. As a result, some of the collaborators in the North Dakota group decided to evaluate some options.

APPROACH:

The Carnegie Math Pathways approach has developed a transformational curriculum for developmental math, offering Statway and Quantway as alternative developmental course sequences that progress students "to and through" their college mathematics sequence. Statway and Quantway utilize a non-traditional intuitive problem-based and collaborative learning pedagogy. Statway and Quantway Pathways engage students in the statistical and quantitative reasoning concepts increasingly seen as more relevant to many students' educational and career goals than those in the traditional algebraic sequence (Huang 2018). Although there is nothing completely new under the sun, this teaching and learning methodology puts several components together in a homogenous classroom operation. Essentially it's answering that collective student question, "am I ever going to use this?". By first introducing a practical everyday scenario to student groups, it places the burden of finding a solution on those very groups who in turn have to devise strategies that answer the questions put forth from the scenario. The instructor acts as a facilitator by first presenting the problem and then by indirectly assisting the individual groups down the proper pathways by way of leading questions that hopefully end in the groups coming to a common answer.

The groups ideally have four students each with each assigned a role: presenter, monitor, facilitator, and recorder. This will give each a job during the proceedings so no one will be excluded from active participation. It will also level the extremes of the participates out somewhat between the extroverts and introverts. In addition, it gives every student a purpose and provides accountability to their group to be in attendance. Every phase of the problem-solving path, from initially understanding what the problem is to the termination of the task by presenting its solution to the rest of the class involves utilizing writing and oral skills to make it a well-rounded educational endeavor.

Stepping back from the details of implementation to compare the Carnegie pathway to the traditional way, consider figure 1 and figure 2 below:

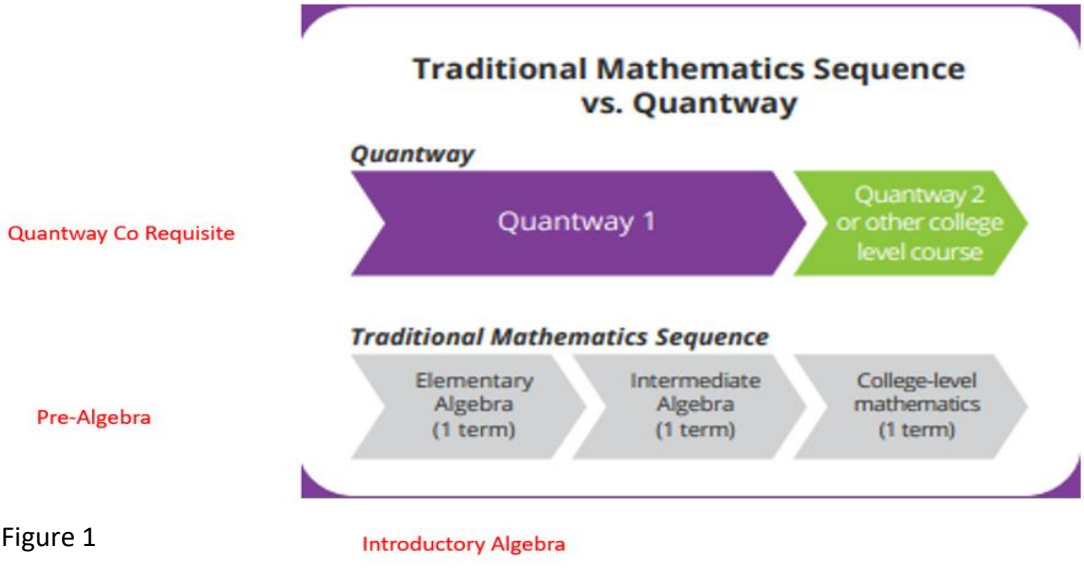
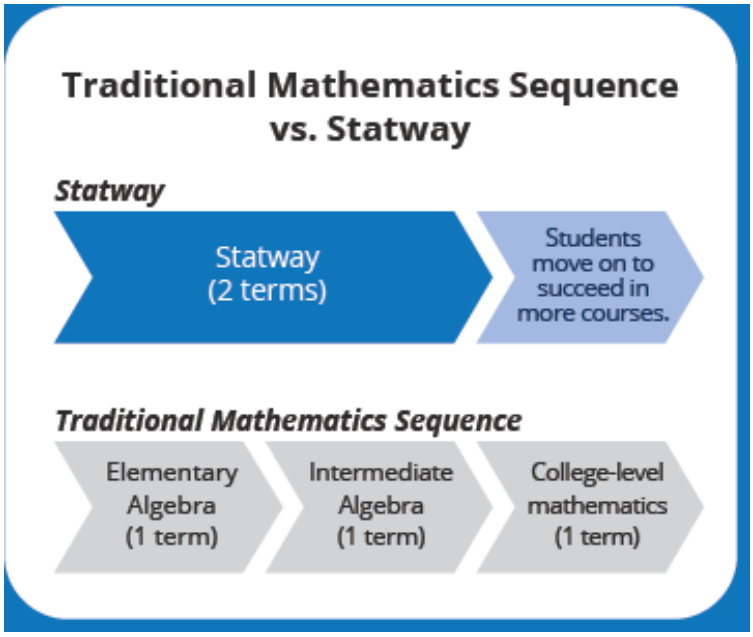


Figure 1

To clarify the red entries in figure 1; Introductory Algebra would be the actual name of the Elementary Algebra directly above it while Pre-Algebra is the initial course and is a term by itself. The Quantway Co-Requisite is incorporated into the Quantway 1 course for those students placing into Pre-Algebra from the placement exam but electing to go the Quantway path. (Quantway 1 is now called Quantway Core and Quantway 2 is referred to as Quantway College). Figure 2 below shows the equivalent Statway sequence.



To reiterate about the concern with the traditional pathway taking up the entire student career at a community college, one can see that both the Quantway and Statway sequences are a shorter path. Students at Cankdeska Cikana Community College, CCCC, which has implemented the Quantway route, non-STEM majors take Quantway 1 and Quantway 2. In the future, there is the possibility that Quantway 2 (Quantway College) along with a co-requisite College Algebra bridge course could potentially replace Math 103 (College Algebra) as a college level Quantiative Reasoning course, therefore fulfilling the ND: Math General Education requirement. For STEM students, who are taking the Quantway path, there is what is known as an 'algebra bridge curriculum' that is incorporated within the Quantway 2 course that would add the necessary rigor to prepare the student for the traditional College Algebra (MA 103) course.

The Quantway routes can be visualized in the CCCC, flow chart in figure 3 that our advisors use when assisting students during registration.

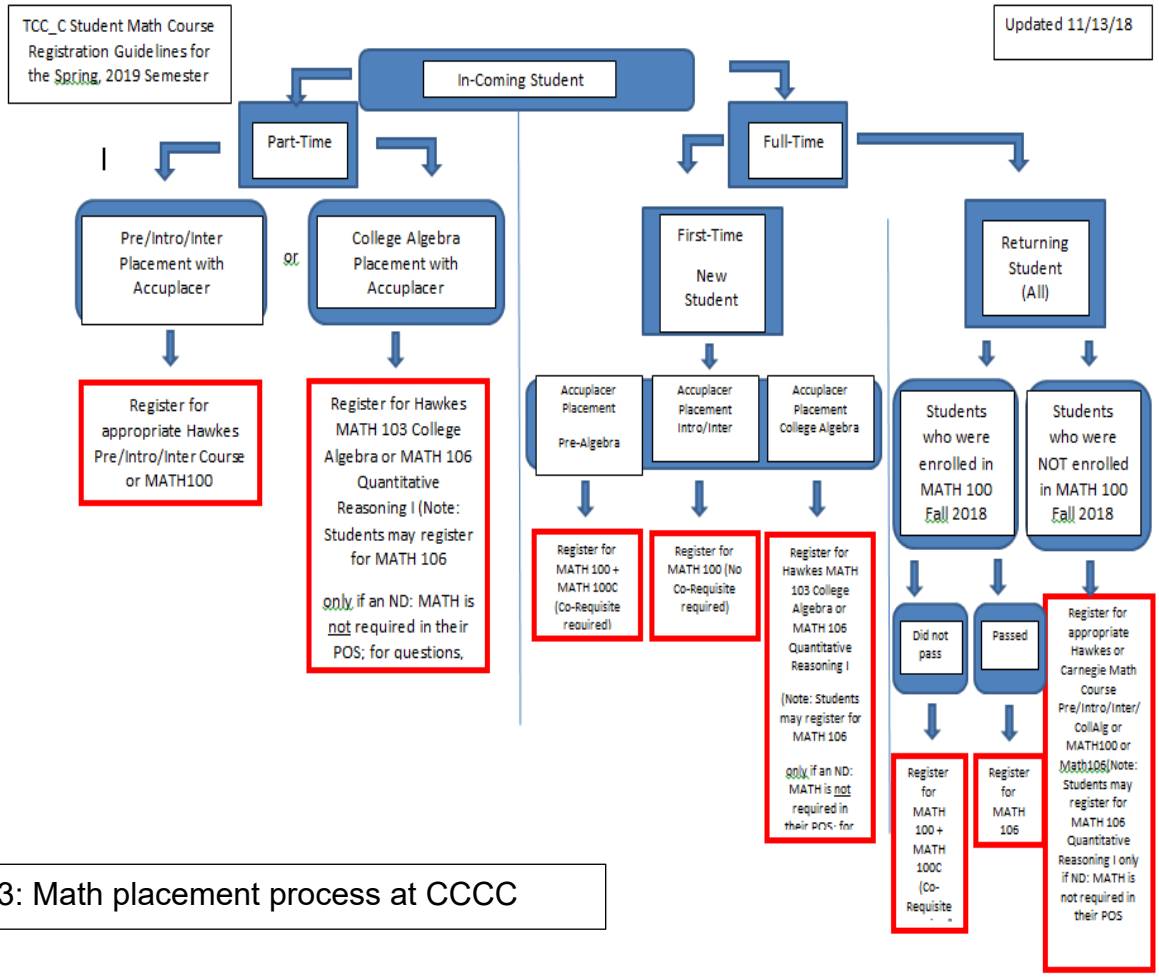


Figure 3: Math placement process at CCCC

For the Statway path at Nueta Hidatsa Sahnish College, NHSC, students take Statway I in semester one and Statway II in semester two. The combination of both courses is equivalent to a college-level Statistics course and is transferrable to North Dakota universities as MA210 – Elementary Statistics. If a student is a STEM major, they take the 1-credit "algebra bridge" co-requisite that prepares a student for College Algebra.

A similar flowchart for Nueta Hidatsa Sahnish College is shown in figure 4.

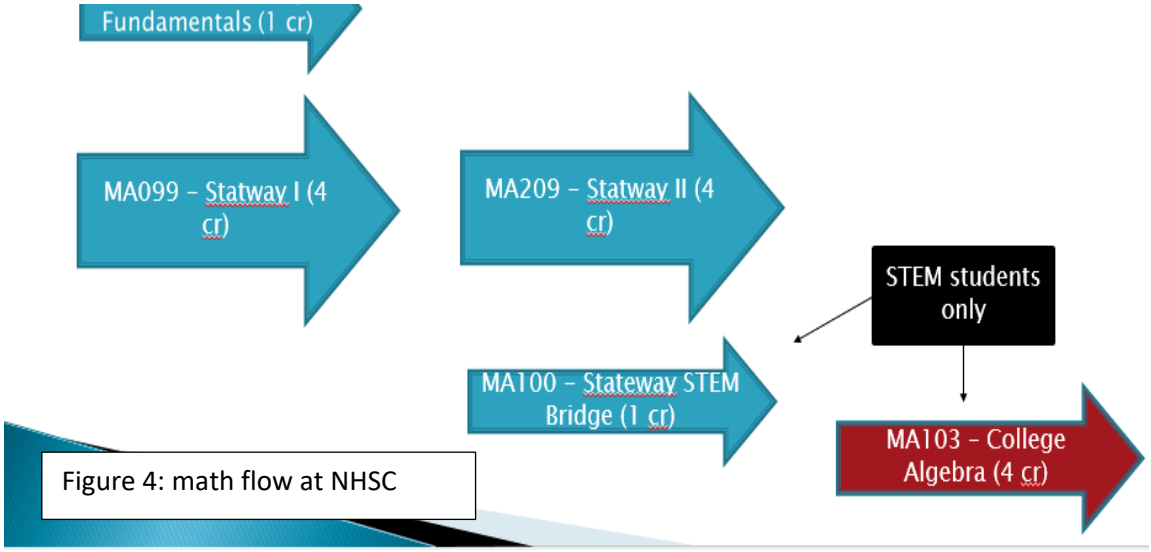


Figure 4: math flow at NHSC

IMPLEMENTATION AND RESULTS TO DATE:

NHSC, implemented the Statway sequence in Spring 2018, while CCCC implemented the Quantway sequence Fall 2018.

NHSC has seen completion success rates score comparable to the success rates in their previous remedial math sequence or math course (pre-algebra, introductory algebra, and intermediate algebra prior to offering Statway).

For NHSC's previous remedial math; Elementary and Intermediate Algebra (Fall 2017) success rates were 28% and 14% respectively. Comparing this with Statway I, the first time they offered Statway I in Spring 2018 semester they only saw a 23% success rate for Statway I-SP18. However, a significant increase was seen in the success rate for Fall 2018, which saw a 43% success rate for Statway I-FA18). Additionally, Fall 2018 was the first offering of Statway II, which had a 50% success rate. This was is a significant improvement from NHSC's traditional algebra-based math sequence.

The impacts NHSC and CCCC have seen in students in Statway and Quantway is that of collaboration among student groups. It has been observed that outside the Statway and Quantway classroom the group members remain close, as friends and collaborators, even working on coursework together for their other classes. Statway

and Quantway group members keep their peers engaged and hold them accountable, which helps improve attendance. It is seen that students have become more committed to each other's success. There is a sense of belonging among students.

This nonmathematical outcome has contributed to the sense of cohort amongst the students and that is one of the directives of the PEEC program as these students prepare for upcoming engineering courses.

CONCLUSIONS:

Reflecting on results since the implementation of Statway and Quantway, the facilitators have noticed that students learn in different ways and how providing problem-based, collaborative learning that addresses those different learning styles has helped the students immensely. The students feel much more comfortable asking their colleagues questions to assist them rather than the instructors. Additionally, improved teaching methods have arisen that follow instructors in their other courses. Teachers are able to switch effortlessly between instructor to being a facilitator of learning. Because of the problem-based, collaborative learning environment of Statway and Quantway, students first have to figure out things for themselves or find ways to answer a problem in their groups before seeking an instructor's help. Also because of the class interaction between students and instructor it breaks down communication walls improving faculty to student relationships which allow faculty to follow up truant students easier than it was before. Students are able to communicate with their peers about some of the challenges they are facing and their peers, in turn, confidentially inform the instructor the reasoning behind a particular students absenteeism.

REFERENCES:

Bailey, T., Jeong, D. W., & Cho, S.-W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. Economics of Education Review, 29 (2), 255-270

Hoang, H., Huang, M., Sulcer, B., & Yesilyurt, S. (2018). Carnegie Math Pathways™ 2016-2017 impact report: A six-year review. Retrieved from Carnegie Foundation for the Advancement of Teaching website: https://www.carnegiefoundation.org/wpcontent/uploads/2018/02/Carnegie_Pathways_IMP_2018

Snyder, T.D., & Dillow, S.A. (2011). Digest of educa.on sta.s.cs 2010. Retrieved from National Center for Education Statistics (Institute of Education Sciences, U.S. Department of Education) website: http://nces.ed.gov/pubs2011/2011015.pdf