Abstract

To improve student success in college-level mathematics courses (and in disciplines with math-dependent content) we aim to enhance student mathematics preparedness and to refine advising and placement. We propose adopting a new strategy for mathematics placement and advising, combined with a “math emporium” model of instruction to remedy deficiencies in preparedness and supplement existing mathematics teaching.

Description

The first component is advising to identify the appropriate mathematics pathway for each student. Many undergraduate degree programs have a mathematics requirement beyond the university core C2 mathematics requirement; some programs require statistics while some take students on a trajectory from algebra through calculus (and perhaps beyond). It is important to develop advising strategies both for the Advising Center and for the program faculty advisors to identify not only which mathematics courses each student should take first but also when. For example, some students would improve their chances of success by enrolling in mathematics courses later in their undergraduate careers, spending earlier semesters confirming their intended major and career goals (and the mathematics required therein) and strengthening background deficiencies.

The second component is accurate placement into the first college-level mathematics course. Through use of a robust placement strategy that considers factors in a student’s record (e.g., standardized test scores and high school grade point average) coupled with a diagnostic of content mathematics skills, we will ensure that each student starts at the proper level course for the chosen degree program. In parallel we will advise every student as to the best path through the mathematics required for the chosen degree program. Choice of a diagnostic and prescriptive instrument to assess skills would require research on effectiveness, scope, flexibility, and cost. A comprehensive placement product such as McGraw-Hill ALEKS ¹ assesses skill level and offers instruction modules to remedy deficiencies, but this type of tool is costly. Commercial assessment instruments (such as College Board ACCUPLACER²) or in-house assessments can determine skill.

¹ http://www.aleks.com/about_aleks/assessment
² https://www.accuplacercat
level but require more campus resources to provide instructional support to address deficiencies.

The third component is to develop a preparation strategy to support those students who arrive on campus underprepared for college-level mathematics. The math emporium model provides a structured and mandated support to alleviate skill deficiencies diagnosed by placement instruments. Adequate study space, tutoring support, and targeted online instructional resources are essential elements of the emporium. This support needs to consider student study habits and strategies consistent with success in college level mathematics courses in addition to skills related to content. Student needs will also vary; preparation for MATH 101 (Mathematical Concepts) or MATH 170 (Applied Statistics) requires different skill sets than MATH 130 (College Algebra) or MATH 146 (Precalculus).

The final component is ongoing tutoring and instructional support for subsequent mathematics courses both in the core and as electives for various degree programs.

**Rationale**

The rationale for this QEP theme is ensconced in our institutional commitment to student success, particularly to help students develop a sense of personal, intellectual, and professional identity [WCU Strategic Plan Initiative 2.1.4]. Since 2009 the DFW rate in MATH 130 (College Algebra) and MATH 146 (Precalculus) has been over 30% while exceeding 40% in MATH 153 (Calculus I). Instructors report that students, even those with substantial math backgrounds, often have not mastered basic concepts. More importantly, many do not know how to study at the college level—that is, to learn (or re-learn and review) independently in order to keep up with the accelerated pace encountered in college level classes. A QEP centered on accurate mathematics placement and effective mathematics preparation would address these critical concerns that impact retention at WCU.

According to our current placement strategy, we place incoming students in mathematics courses solely on SAT mathematics scores. (ACT scores can be converted by a concordance, and students who attempt AP Calculus AB with a score of 2 are exempted from the SAT placement. AP and CLEP credits come in as transfer credits for the appropriate course.) The resulting placement is crude, relying heavily on a single instrument that is not designed to analyze mathematical ability beyond basic content knowledge. As a result, students have found themselves in mathematics courses in which they have little probability of success. Many students are not prepared for MATH 130 (College Algebra), an important gateway course towards mathematics required for STEM careers and the lowest level mathematics course available for these scientific and technical programs. Any traditional course below College Algebra would be considered remedial and cannot be offered for college credit. However, beyond the support provided by the Mathematics Tutoring Center, which is a totally voluntary drop-in tutoring program, WCU cannot currently help these students with additional content
preparation. We need data, in the form of placement results, to mandate that students solidify their knowledge and skills.

Of our peer institutions of higher education in the UNC system, only two others (NC A&T and UNC-C) have no placement exam whatsoever. Several combine predictors from the student application (such as SAT/SAT Math Level II and HS GPA) with a placement exam score for placement. Some use placement exams but exempt students with high scores on standardized tests. Clearly, employing more significant indicators improves the accuracy of the placement, and there is strong evidence linking proper initial mathematics placement to student retention and success.

John Wagaman, Department of Mathematics and Computer Science, and Johnny Lail, Office of Institutional Planning and Effectiveness, analyzed five years of freshman cohort data, concluding that of several possible factors correlated to student success in a mathematics course at WCU, only SAT MATH score and un-weighted high school GPA are significant predictors of student success. Using this evidence, they constructed a placement model using a grid that cross-references these two factors and returns a probability of success in each of the entry-level courses. Ironically neither the specific mathematics coursework taken in high school nor the actual grades in high school mathematics courses are significant predictors of success, based upon grades received in WCU courses. (This is consistent with the wide range of mathematical competencies observed anecdotally in new MATH 130 students). With the cooperation of the Advising Center, we are beta-testing this new placement model on the incoming new students for Fall 2015. However, even this slightly better model is imprecise, as neither factor directly measures mathematical content knowledge or outright mathematical ability.

We do not want capable students with weak preparation to be shut out of careers requiring basic mathematics; rather, we wish to encourage students to choose STEM majors and to keep those STEM majors on track to on-time graduation. To that end, we seek a strategy in teaching and learning mathematics that can accurately assess students’ strengths and weaknesses, provide them with a mechanism to fill in gaps in mathematical content knowledge, and to place each student in the most suitable mathematics course. This strategy will enhance mathematics classroom instruction and supplement the present drop-in tutoring support with customized diagnoses and prescriptive enrichment to improve students’ chances of success in these mathematics courses.

**Scope and Impact**

---

3 NC EMPT annual report 2014-2015
4 See, for example, Edgar J. Fuller and Jessica M. Deshler, “The Effect of a New Placement Process on Student Success in First Semester Calculus, Creative Education 4(9), 18-21, http://www.scirp.org/journal/ce
Success in mathematics courses has broad impact across the university. Proper placement is essential for all majors with mathematics course requirements beyond the C2 mathematics core requirement, and it can potentially be expanded to support course planning for students who only need to satisfy the C2 requirement. A placement strategy that improves success in math courses may also positively impact student retention from first to second year [WCU Strategic Plan Initiative 1.6.7] as well as the six-year graduation rate [Initiative 1.6.8]. Improving graduation efficiency will also support the institutional goal of increasing the number of graduates prepared for the workforce [Initiative 1.1.7].

Another component of placement that contributes to student success is to identify when a student should start taking mathematics courses. Generally, students are advised to avoid letting time pass between the last high school math course and the first college mathematics experience. A placement scheme that also provides, through the math emporium model, a review of basic skills would allow students to take the time to confirm their major/career goals and adjust to college academic demands before tackling college-level mathematics courses. Ideally the preparation could vary in length and could be customizable to students’ needs, while avoiding the dangerous temporal gap between high school and college math experiences.

The emporium model would necessitate heavy support from tutors, software selection and preparation, and information technology support. Tutoring experience is an important educational component for students going into teaching careers, and as application experience for STEM majors. Selected software could be integrated into coursework and curriculum, in addition to supporting the math emporium. Hardware needs are somewhat alleviated by the requirement that students have a laptop computer, and that WCU has a well-supported wireless system to take the place of a dedicated computer lab.

Another potential use of the placement and emporium model is to improve articulation from community colleges, particularly in the face of the increasing number of students receiving transfer credits through early college coursework. In cases in which transfer credit has been awarded, a placement diagnostic may identify areas in which the transfer student would benefit from supplementation. This can close any gaps in content and mastery in transition from community college instruction to WCU and ameliorate students’ adjustment to the faster pace of instruction at WCU. (For example, MATH 146 proceeds through the same mathematics content at essentially twice the speed of the analogous courses in the NC community college system.) Analysis of data from diagnostics could also lead to curricular changes to mathematics coursework to improve responsiveness to student needs.

Assessment
The math emporium model has been very successful in institutions nationally.\(^6\) In addition to student success in subsequent mathematics courses, other outcomes include motivation, self-efficacy, and self-confidence in learning mathematics’ [Helming and Schweinle, 2014]. The impact of placement lends itself well to assessment. Assessment instruments could easily capture data from the courses themselves and analyze data from student transcripts and registrar records. Potential measurable outcomes are summarized in the table below.

<table>
<thead>
<tr>
<th>Student Outcome</th>
<th>Means of Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be more successful in their first mathematics course (decrease DFW rates)</td>
<td>Track DFW rates in Math 130</td>
</tr>
<tr>
<td>STEM students will be more successful in subsequent math courses</td>
<td>Longitudinal tracking of STEM students; tracking DFW rates in subsequent courses; correlate with use of emporium model</td>
</tr>
<tr>
<td>Improve first year fall-to-spring and first-year to second-year retention rates</td>
<td>Track retention rates</td>
</tr>
<tr>
<td>Improve graduation rates</td>
<td>Monitor graduation rates for math-intensive majors</td>
</tr>
<tr>
<td>Students will gain confidence in mathematical ability</td>
<td>Pre- and post- enrichment and course surveys</td>
</tr>
<tr>
<td>Improve retention of STEM discipline majors</td>
<td>Track numbers of majors, monitor progress to graduation</td>
</tr>
</tbody>
</table>
