

First Year Mathematics at Western Washington University: Observations, Conclusions, and Recommendations

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Preface

I was asked by the Chair of the Math Department to examine the first-year math courses at Western Washington University with particular attention to MATH 112 Functions and Algebraic Methods and MATH 114 Precalculus I. These two courses have the lowest success rates (59% and 61% for Fall 2011-Summer 2016, respectively) and largest enrollments of the first-year math courses.

I intended to examine, as much as possible, the content and pedagogy of individual courses, the resources available to support students in first-year math courses, the organization of Quantitative and Symbolic Reasoning (QSR) portion of the General University Requirements (GURs), the structure and culture of the Math Department and the University as a whole as it relates to the first-year math courses and the GURs, the means by which students are advised into and navigate first-year math courses, and the physical facilities available for the teaching of math classes.

These observations are composite pictures assembled from the various interviews conducted by the author April 24-26 and May 22-23, 2017, data and statistics forwarded to the author by various members of the Western Washington University faculty and staff, and material posted by Western Washington University at wwu.edu.

The Western Washington University community, by and large, sees the success rates in first year math courses as problematic, particularly in MATH 112, the largest enrollment math course, and MATH 114, the second largest enrollment course and the gateway to STEM. A more forceful statement is that the DWF rate in these courses is unacceptably high.

In the absence of sequence success rates calculated by tracking of individual students, sequence success rates may be very roughly approximated by using products of individual course success rates. The included table represents four tracks for completing the QSR and four representative tracks for entering specific math-enhanced majors

| Pathway | Course Sequence | Probability of completing pathway without repeating a course |
|----------------------------|---------------------|--|
| QSR options 1/2 | 112-107 | 44% |
| QSR option 4 STEM | 112-114 | 36% |
| QSR option 4 BUS | 112-156 | 45% |
| QSR option 4 STAT | 112-240 | 50% |
| Complete Precalculus | 112-114-115 | 26% |
| Single Var Calculus (STEM) | 114-115-124-125 | 23% |
| Single Var Calculus (STEM) | 112-114-115-124-125 | 14% |
| Business Calculus (BUS) | 112-156-157 | 39% |

I approached the task fully understanding that at state supported universities, budgets can be volatile and planning processes are hampered by annual/biennial budgets allocated by a legislature that is largely focused on the current budget cycle. When coupled with the essentially conservative nature of academia, the financial uncertainty makes curricular change hard. Rapid changes in student enrollment and program interest drive staffing decisions and bring more but less fully invested faculty.

Nothing that I encountered at Western Washington University is unique to WWU. The combination of impediments to student success and structural resistance to change is, however, unique and perhaps more challenging than at similar institutions.

Executive Summary

The Western Washington University community is concerned with the success rates in first year math classes. The concern is not with the courses per se; rather the concern is that students' lack of success is decreasing student retention, access to programs, and program completion, ultimately leading to decreased four and six year graduation rates.

The math department, as well as the math faculty working individually and in small clusters, has begun to examine courses and their teaching, but significant structural barriers exist that inhibit change. Implicit in the following recommendations is the removal of those barriers.

The current curriculum and departmental/university structure have evolved over the course of many years; meaningful change will require both significant effort and a timeline measured in years. The following recommendations are made with that in mind, presented in an order that is not meant to imply priority, complexity, or effort required.

Recommendation I: Instructors who teach courses should participate fully in the design, assessment, and revision of the courses.

Recommendation C: Each first-year course cluster or sequence should have a faculty member coordinate the various sections of the course to offer students a more uniform experience section to section.

Recommendation P: Reexamine the pedagogical approach of first-year math courses and consider the inclusion of more active and student-centered learning.

Recommendation O: Reexamine the course objectives of MATH 112, MATH 114, MATH 115, and MATH 118 with an eye toward refocusing the courses on a smaller number of key objectives.

Recommendation Q: Reexamine the options and pathways for fulfilling the Quantitative and Symbolic Reasoning requirement with an eye toward simplifying or streamlining the QSR requirement.

Recommendation A: Change advising practice so that students who do not express interest in studying fields that require calculus or significant algebra are directed to a QSR path other than 112-114 or 112-156.

Recommendation S: Reexamine course scheduling including meeting duration and section sizes to facilitate changes in pedagogical approaches developed from Recommendation P.

Recommendation F: Reconfigure physical classrooms as needed to support Recommendations P and S.

The Recommendations:

Recommendation I: Instructors who teach courses should participate fully in the design, assessment, and revision of the courses.

This recommendation applies to instructional faculty regardless of rank. Current scheduling practice has courses through single variable calculus taught predominately by non-tenure track instructors (NTTs). Under the supervision of a lead instructor, graduate teaching assistants (TAs) teach a significant number of course sections, particularly in the 112-114-115 sequence. Should the role of graduate teaching assistants change (for example, to providing supplemental instruction rather than primary instruction), they should continue to participate in the assessment and revision of courses.

Each course should have an agreed upon set of content objectives and learning outcomes. These outcomes and objectives should be easily accessible by faculty and given to all faculty as they teach the course for the first time or as they return to the course after an extended absence.

Development and revision of the objectives and outcomes should be as inclusive a process as possible. Broad participation by faculty means that the objectives and outcomes cannot be arrived at by consensus; rather, a fair and clear process, including majority or supermajority approval methods for objectives and outcomes, should be designed and implemented. A similar process should be used to approve the entire package of outcomes and objectives.

Once in place, content objectives and learning outcomes should be assessed. The limited availability of time and resources will restrict this assessment to a small number of key objectives, and perhaps one or two general learning outcomes. Assessment tools should be developed by the faculty who teach the course. They should be uniform over across course sections and semesters.

Assessment of courses should include success rates in courses, in successor courses, and through entire sequences. Overall rates as well as success rates for populations of interest or concern (e.g., first generation, Fall true first-year students, minority) should be examined.

While assessment data should be collected and examined regularly, review and revision of courses is a large task and need not be done annually. However, review and revision of courses should be expected on a regular schedule.

Recommendation C: Each first-year course cluster or sequence should have a faculty member coordinate the various sections of the course to offer students a more uniform experience section to section.

Recommendation I calls for the adoption, use, and assessment of content objectives and learning outcomes for each course. While all the instructors who teach the course should be involved in the process, without a clear point of responsibility for each course, the initial cohesion of the courses will diminish. Individual instructors tend to modify the course each time they teach it, resulting in a curricular drift similar to the genetic drift within a species. Genetic drift can result in speciation, and, similarly, curricular drift can result in two sections of the same course being relatively incomparable.

Courses do not exist in a vacuum. Each course fits a niche within the QSR portion of the GURs, within a course sequence, and within the curriculum as a whole. The role of a course coordinator should include ensuring that the course continues to fit within its niche and does the job expected of it by later courses and by the GURs. Courses that are part of a clearly defined sequence such as precalculus (Math 114/Math 115) or single variable calculus (Math 124/ Math 125) naturally group together and can be efficiently coordinated by a single person with less total effort than using individual coordinators for the different courses in the sequence.

Ensuring a uniform experience section to section does not mean that each section need be the same, use common tests, use common homework sets, or use any other common element beyond that used for assessment of the course.

Uniformity implies that the difficulty level of exercises and assessments does not vary greatly from one section to another. For example, for the hypothetical content objective “factor a trinomial with lead coefficient not equal to 1,” a student in one section should not be expected to be able to factor $21p^2 - 75p + 36$ on a test while in another section the student is expected to be able to factor nothing more complex than $2x^2 + 11x + 5$.

Uniformity implies a reasonable correlation of schedule section to section. Students who are enrolled in different sections are more able and more likely to work together if they are learning and practicing the same content. This is of particular advantage in the various tutoring facilities on campus. The time available for tutors to work with individual students is limited. If the students are all working in the same block of material, the tutors can more easily help multiple people at a time, and the students in the tutoring center can more easily help each other while the tutor is otherwise occupied helping somewhere else.

Recommendation P: Reexamine the pedagogical approach of first-year math courses and consider the inclusion of more active and student-centered learning.

Students who are actively involved with peers, faculty, and staff – especially in learning activities – are more likely to learn, persist, and graduate.ⁱ Straight lecture is rarely demonstrated to be more effective than other delivery methods. Freeman et.al., found that math students were nearly half again as likely to fail a math course whose pedagogy was primarily lecture rather than student-active methods.ⁱⁱ The effect was strongest in class smaller than 50 students. Using active learning pedagogies has been demonstrated to improve student grades and lower failure rates in STEM classrooms, addressing the issue of pass rates in mathematics courses as well as continuation into the STEM pipeline.ⁱⁱⁱ

Active learning and student centered pedagogies can also contribute to University efforts to integrate first generation students into the community, providing peer support and opportunities to address imposter syndrome.^{iv}

Co-requisite classes should be considered as a method to improve success rates and retention. Identified students are required to attend a co-requisite class with a defined curriculum that provides targeted support to help boost their understanding and learning of prerequisite and college-level course material. These classes provide additional opportunities to decrease student anxiety, develop faculty and peer relationships, organize study groups, and provide knowledge about other support services at the University, including tutoring centers.

All faculty benefit from targeted professional development in active learning and student centered pedagogies, on or off site. Other models for continuing professional development include faculty learning groups, teaching seminars, and research in the teaching and learning of mathematics.

Recommendation O: Reexamine the course objectives of MATH 112, MATH 114, MATH 115 and MATH 118 with an eye toward refocusing the courses on a smaller number of key objectives.

MATH 112 and MATH 114 have the lowest success rates (59% and 61% for Fall 2011-Summer 2016, respectively) and largest enrollments of the first-year math courses. MATH 115 and MATH 118 have better success rates (71% and 67% for Fall 2011-Summer 2016, respectively) and smaller enrollments, but are key course for students intending to enter a STEM field. Taken as a sequence, MATH 112-114-115 is the largest barrier for students completing the QSR portion of the GURs and the largest barrier for students wishing to enter a STEM field.

Across constituencies, people voiced concern with the pace and breadth of content of the courses, most strongly for MATH 112, a major concern because of its role in the QSR portion of the GURs. While students often say this about math classes, the instructors who teach the courses made similar statements. Both MATH 112 and MATH 114/115/118 are tied to text books that were originally published in the mid 1990's and have not been revised for more than a decade. Over time, the Math Department has created supplements that add additional content to the courses.

Under the direction of the course coordinator, faculty of all ranks who teach each course should compose a list of course objectives as the course is currently taught. Objectives that are not part of the core theme of the course and are not required for the immediate successor courses, particularly MATH 124/Math 125, should be considered for elimination. The course coordinator for MATH 124/MATH 125 may serve as a liaison to the faculty who teach MATH 124/ MATH 125 in this process.

Recommendation Q: Reexamine the options and pathways for fulfilling the Quantitative and Symbolic Reasoning requirement with an eye toward to simplifying or streamlining the QSR requirement.

The following is taken from the General University Requirements Checklist 2016-17

| | |
|--|---|
| <p>Quantitative and Symbolic Reasoning (QSR):</p> <p><input type="checkbox"/> Complete 1 of 6 options</p> <p>Note: If choosing options 1, 2, or 3 seek advising before completing coursework</p> <p><input type="checkbox"/> MATH 107, 112, or MPAR</p> <p><input type="checkbox"/> _____ Additional QSR course</p> | <ol style="list-style-type: none"> 1. MATH 107 <i>and</i> one course from: ANTH 335, CSCI 103, 172, ENVS 201, 221, FIN 216, MGMT 201, MATH 112, PHIL 102, SOC 304 2. MATH 112 <i>and</i> one course from: ANTH 335, CSCI 103, 172, ENVS 201, 221, FIN 216, MGMT 201, MATH 107, PHIL 102, SOC 304 3. One transfer course with MPAR <i>and</i> one course from: ANTH 335, CSCI 103, 172, ENVS 201, 221, FIN 216, MGMT 201, MATH 112, PHIL 102, SOC 304 4. One course from: MATH 114, 115, 118, 124, 134, 156, 157, 160, 240, CSCI 138, 139, 140, 141, 145 5. One course with an MSAT attribute 6. BAE-Elementary Education students only: MATH 381, 382 |
|--|---|

http://www.wvu.edu/advising/doc/GUR_Checklist.pdf

The language and abbreviations are difficult for students, especially first year students, to understand. Two key abbreviations are present: MPAR and MSAT. A search for MPAR using the WWU site search produced 19 results. Definitions of MPAR (Transfer course meets the QSR GUR in part) and MSAT (Transfer course meets the QSR GUR in full) existed only in the Viking Advisor and at the Understanding Your TER subheading on the New Transfer Student Advising page. The differing usage “One transfer course with MPAR” and “One course with an MSAT attribute” is inconsistent, making it less transparent to the novice reader. Replacing that language with the definitions would remove the confusion. MPAR and MSAT can be used as attributes on the Transcript Evaluation Reports (TER).

The requirement itself is unnecessarily complex. The first three numbered options are essentially identical and characterized more succinctly in the shaded box at the lower left. Consolidating the three into a single option would reduce complexity for the novice reader without changing the QSR requirement itself. Care would need to be taken to preserve the actual meaning of MPAR, which *seems to be* a math course that neither is equivalent to intermediate algebra nor has intermediate algebra as a prerequisite.

The QSR section of the General University Requirements is the only section that specifically cites transfer courses. Inclusion of option 5, one course with an MSAT attribute, is therefore extraneous.

Looking at only the math courses in the QSR requirement, it is impossible to complete the QSR requirement without completing MATH 112 or demonstrating similar algebraic skill via some placement device. Stepping back and looking at the overall requirement, the first way to complete the QSR requirement is MATH 107 and ANTH 335. ANTH 335 *does not* have MATH 112 as a prerequisite. Pathways exist to complete the QSR requirement without competing MATH 112 or its equivalent. The math department should consider creating an additional quantitative methods course, perhaps an entry level statistics course, as an additional QSR course in order to give students the opportunity to complete the QSR requirement using math courses without significant traditional algebra content.

Recommendation A: Change advising practice so that students who do not express interest in studying fields that require calculus or significant algebra are directed to a QSR path other than MATH 112-114 or MATH 112-156.

MATH 112 is a key course for students who are interested in pursuing fields of study with significant math content. The course plays an important role within the traditional algebra-precalculus-calculus STEM pathway, and must include significant algebraic content. However, for many fields of study, algebraic proficiency at the level of MATH 112 is unnecessary.

Recommendation Q advocates a simplification and restructuring of the QSR requirement to facilitate the use of non-algebra dominated pathways to completion of the QSR requirement. The culture of Western Washington University discourages students from declaring major in their first year. However, advisors can use student interest information to help students choose a path through the QSR that is more likely to lead to success and more likely to be relevant to their major when it is finally declared.

Faculty should backstop advisors in this effort by asking students about their academic and career plans at the beginning of the quarter. Should the course the student is enrolled in not be the best choice for their academic and career plans, the faculty member should suggest that the student seek supplemental advising and/or reconsider the choice of math class.

Recommendation S: Reexamine course scheduling including meeting duration and section sizes to facilitate changes in pedagogical approaches developed from Recommendation P.

Recommendation P advocates changing pedagogy to include less lecture and more student active techniques. Most such techniques are difficult or impossible to implement effectively with classes in excess of 40 students. They require one-to-one or one-to-few interaction between the instructor and the students or within student groups.

Recommendation F: Reconfigure physical classrooms as needed to support Recommendations P and S.

A committee comprised of faculty from all ranks including TAs as well as an administrative representative should research classroom furniture, technology, and display options for faculty and student work. The committee should seek a configuration that maximizes flexibility, quick rearrangement, access for students with disabilities, and movement within the classroom. Physically visiting classrooms with these attributes at WWU or other institutions is strongly recommended.

Proposed Action Plan

Fall 2017:

- Continue the work of the faculty group that is currently addressing pedagogical issues in MATH 112. This work group should disseminate its results and/or be expanded to include all instructors, of any rank, who teach MATH 112 or are likely to do so in the near future.
- Plan for reduction in class sizes, particularly in MATH 112.
- Identify changes to classroom facilities to support active learning strategies.
- Reopen the search for a Director of First Year Math.
- Discuss as a department potential additional QSR course(s).

Winter/Spring 2018:

- Hire a Director of First Year Math.
- Identify coordinators for individual courses and course clusters not likely to be coordinated by the Director of First Year Math.
- Establish guidelines for constructing and ratifying of course objectives.
- Establish a schedule for course review and revision.
- Review and revise MATH 112.
- Request course success rates, successor course success rates, and sequence success rates from the Office of Institutional Research. Include both overall rates and rates for populations of interest and concern.
- Revise the QSR requirement language in the course catalog and ensure that the language is used clearly and uniformly across university publications.
- Discuss as a department simplifying the number of options listed in the QSR requirement.
- Discuss as a department a plan for professional development.

Fall 2018:

- Expand work on pedagogical issues vertically and laterally in the curriculum. Focus on the precalculus courses MATH 114/115/118 and MATH 107.
- Formalize course clustering and course coordinators. Course coordinators call meetings of the teaching faculty for each course or course cluster.
- Review and Revise MATH 114/115/118. This will continue into 2019.
- Enact the departmental plan for professional development.

2019 and Beyond:

- Continue work on Pedagogical issues. Expand to the single variable calculus courses MATH 124 and MATH 125.
- Continue course review and revision following the established schedule.

Director of First Year Math

The job of improving and coordinating the first year math experience at Western Washington University is too big for a single person. Some of the coordination work will need to be done by other interested and empowered faculty.

Although it is hard to include in a bullet-pointed job description, perhaps the most important duty and responsibility of the Director will be to go out and advocate for first year math within the Math Department and across Western Washington University. And that has to be done without stepping on the toes of the Chair of the Math Department or the various other directors, coordinators, and administrators across the University. This is not a job for an inexperienced faculty member.

The ideal candidate for this position would be a midcareer mathematician with significant experience teaching developmental or introductory mathematics and an ongoing interest in these courses. The candidate should also have leadership experience as well. This leadership experience could be in a similar kind of director/coordinator position, direction of a tutoring center or similar facility, or the chairing of significant administrative or faculty governance committees.

In the first year or so, and perhaps continuing into the future, the teaching load for the Director should be reduced. The courses taught should be predominately drawn from the first year courses. One teaching plan might be for the Director to start with MATH 112 and work sequentially through MATH 125.

Scholarship expectations should also make sense with the proposed work. Expect that the scholarship produced by the director will be primarily derived from her or his work with the pedagogy of the first year courses or the assessment of those courses.

The duties are recommended for a Director of First Year Math.

- Act as course coordinator for MATH 112 and the precalculus group MATH 114/115/118.
- Act as coordinator of the course coordinators.
- Advise the Chair of the Math Department regarding the staffing of first year math courses.
- Act as liaison to campus support organizations, specifically including the Tutoring Center, Advising, and Admissions.
- Coordinate the assessment of first year math courses and sequences.
- Act as liaison to departments across campus with regard the content and purpose of first year math courses.
- Arrange, coordinate, and/or facilitate professional development activities for faculty who teach first year math courses.

ⁱ Vincent Tinto, Active Learning Increases Student Performance In Science, Engineering, And Mathematics, Pell Institute for the Study of Opportunity in Higher Education, July 2004,
http://www.pellinstitute.org/downloads/publications-Student_Retention_and_Graduation_July_2004.pdf

ⁱⁱ Scott Freeman et al, Active Learning Increases Student Performance in Science, Engineering, and Mathematics, *Proceedings of the National Academy of Sciences*, June 10, 2014 vol. 111 no. 238410-8415
<http://www.pnas.org/content/111/23/8410>

ⁱⁱⁱ Ibid.

^{iv} Jennifer Engle and Vincent Tinto, Moving Beyond Access: College Success for Low-Income, First-Generation Students, Pell Institute for the Study of Opportunity in Higher Education, 2008
http://www.pellinstitute.org/downloads/publications-Moving_Beyond_Access_2008.pdf