Ohio Mathematics Initiative

Rethinking Postsecondary Mathematics

Final Report of the Ohio Mathematics Steering Committee

March 2014

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Engaging mathematics in Ohio's completion agenda

A letter from Chancellor John Carey

Ohio's ability to compete and to win in the 21st century's global economy depends on its citizens' capacity to succeed in jobs that require advanced knowledge and skills – the kinds of jobs that are available only to those who have earned a bachelor's degree, associate degree or a postsecondary certificate with value in the marketplace.

This is why my primary mission, as Chancellor, is to dramatically raise college completion rates and to increase the number of Ohioans earning a postsecondary credential. In this context, I am committed to doing everything possible to ensure that all college-bound high-school graduates are college ready, and to increase the number of high school graduates with credit toward a college degree or certificate. I am determined to increase the number of community college graduates earning bachelor's degrees through guaranteed pathways to completion, and to align our postsecondary programs with the state's workforce and economic development efforts – particularly in fields related to the STEM disciplines (i.e., science, technology, engineering and mathematics).

During the past year, I have worked with University System of Ohio (USO) campuses across the state to lay the groundwork for implementing the Complete College Ohio Task Force's strategic recommendations for increasing the percentage of Ohioans with postsecondary degrees and certificates. In December 2013, I delivered my recommendations for the College Credit Plus program to Governor Kasich and legislative leaders. These recommendations seek to establish clear requirements and goals for a robust and effective system of dual credit in the state of Ohio.

Last year, the Ohio Board of Regents (OBR) launched two other initiatives in support of our college completion agenda. The first, *PLA with a Purpose*, has been designed to make Ohio a leader in recognizing and embracing the college-level knowledge and skills that students have acquired outside the collegiate experience. With the recommendations generated by this group of more than 140 representatives from campuses across the state, Ohio's universities, colleges and adult career-technical centers will advance and promote the awarding of credit to students for prior learning based on transparent, consistent, rigorous statewide standards. Institutions will transcript, apply and transfer credits awarded on the basis of the statewide standards.

The second initiative is the focus of this report. The importance of the Ohio Mathematics Initiative is beyond question because mathematics is a major stumbling block for so many of our postsecondary students. There is another reason why the work of the Ohio Mathematics Steering Committee is so critical. Much of 21st century science and engineering is going to be built on a mathematical foundation. Yet, the reach of the quantitative sciences doesn't stop there. They are fueling innovation and discovery in many areas. Medicine, manufacturing, transportation, communication, finance and other economic enterprises depend on the mathematical sciences, which consist of mathematics, statistics, operations research and theoretical computer science.

OHIO BOARD OF REGENTS' CHARGE TO THE MATHEMATICS STEERING COMMITTEE

To develop expectations and processes that result in each campus offering pathways in mathematics that yield
(1) increased success for students in the study of mathematics;
(2) a higher percentage of students completing degree programs; and
(3) effective transferability of credits for students moving from one institution to another.

I am proud to share the results of the Steering Committee's work. As you read through this report, you'll see that the initiative has responded squarely to the charge the Regents put before it by giving us a roadmap for (1) developing high-quality entry-level courses and pathways; (2) promoting the effective transfer of course credits; (3) building an Ohio mathematics community with the capacity to identify and scale up best and promising practices; (4) collecting, analyzing and sharing data relating to the effectiveness of postsecondary mathematics programs and practices, and (5) aligning secondary and postsecondary mathematics content and instruction.

Those who contributed to this work are to be commended for the time and effort put into developing this report. Yet, we all know that none of the actions advanced here will happen without the full commitment of those who lead our USO institutions, as well as chairpersons and faculty members in mathematics departments across the state. The Ohio Board of Regents is ready to work with these and other stakeholders to turn the words on these pages into the concerted actions required to transform mathematics in ways that shorten Ohioans' path to college completion and make Ohio more competitive in the 21st century economy.

Sincerely,

John Carey
Chancellor

Why study mathematics?

In 2010, a bipartisan group of U.S. Senators and Members of the U.S. House of Representatives asked the leaders of three esteemed organizations – the National Academy of Sciences, National Academy of Engineering and Institute of Medicine – to assess the nation's competitiveness in a global, technology-driven economy. They asked the presidents of these organizations to update their findings, reported five years earlier, that foreign competition in scientific and technological innovation was undermining the nation's pre-eminence in these areas.[1]

Responding to this request, the three presidents reported that America's competitive position in the world faced, in 2010, even greater challenges, made more serious by several years of economic turmoil and by the rapid and persistent worldwide advance of education, knowledge, innovation, investment and industrial infrastructure. They concluded that the nation's competitiveness in the global marketplace requires a highly qualified workforce, which "demands that virtually all job-seekers be at least 'proficient' in mathematics and general science and that the nation have a cadre of highly creative individuals who possess an extraordinary capacity for mathematics, science and engineering."[2]

This assertion gives us a firm starting point for answering two foundational questions:

1. Why should Ohio's education policy leaders – both statewide and at the institutional level – be concerned about the knowledge and skills students acquire in college mathematics courses, and what's to be accomplished by revisiting and rethinking the pathways to and through the mathematics curriculum in the state's two- and four-year colleges and universities?
2. Why now? Why is this the right time to address these issues and to transform the teaching and learning of mathematics in Ohio's public universities and colleges?

There are many reasons why we teach mathematics to postsecondary students *and today's economic imperative is only one of the factors driving efforts to get higher education's curriculum and delivery methods updated.* For some, it's a discipline of choice, an exciting opportunity to be part of an academic pursuit that has been called the "linchpin of twenty-first century research and technology."[3] For many others, we teach mathematics to give them the tools they need to succeed in mathematics-dependent disciplines, such as the physical and biological sciences and engineering. This constituency is growing rapidly as the mathematical sciences have become central to many of the social sciences, medicine, the environmental sciences, business and finance, advanced design and other disciplines.

At the broadest level, mathematics is advanced for its own sake – for its ways of thinking and the habits of mind and diligence required for success in this and many other fields of study. Mathematics gives students needed quantitative tools, logical reasoning, analytic and problem solving skills, and a sense of the quantitative modeling that can be used to describe developments in many areas of our lives.

[1] National Research Council. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press, 2007

[2] National Research Council. *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. Washington, DC: The National Academies Press, 2010

[3] National Research Council. *The Mathematical Sciences in 2025.* Washington, D.C.: The National Academies Press, 2013, p. 2

Yet, as the mathematical sciences' reach has become broader and their impact potentially greater, there is a growing realization that Ohio's public universities and colleges need to revisit and rethink their mathematics curriculum as well as mathematics' relationships with other disciplines. It is not surprising that this kind of periodic updating is needed. There is something else we must do – find ways to change the notion of mathematics as something to be feared to mathematics as something that can contribute to a learner's career objectives and the quality of her or his life.

But why now? Why is this the right time – a time of exceptional opportunity – to resolve these and other issues?

Perhaps the most compelling answer is reflected in the words of William "Brit" Kirwan, a mathematician and chancellor of the University System of Maryland, and a former president of The Ohio State University, who recently called mathematics the "#1 barrier to college completion."[4] Why? In part, it's because of people's anxiety about mathematics and their lack of appreciation for the quantitative sciences as ways of thinking. But Chancellor Kirwan thinks there are deeper answers that require a comprehensive rethinking of how mathematics courses are structured, how they are taught and how they are connected to students' education and career objectives.

There are other reasons why this is the right time to reassess the teaching and learning of mathematics:

- In recent months, mathematics faculty who are familiar with the Ohio Transfer Module (OTM) have reported increasing difficulties with current processes and criteria for course and credit transfer.
- With the state's adoption of Ohio's New Learning Standards (NLS), a new generation of mathematics students soon will be entering our public colleges and universities. We must be ready to meet their needs and challenge them to succeed in their mathematics courses.

Discipline leaders call for changes in mathematics education

Calling this an especially crucial time for the mathematical sciences community, David M. Bressoud, Eric M. Friedlander and C. David Levermore recently urged their colleagues to review their focus on postsecondary mathematics education.

"We are at a crucial juncture. Members of the academic mathematical sciences community should recognize that *change is coming rapidly* in their world. There is great pressure to reduce costs in order to relieve state budgets and student debt; this *pressure will translate to 'efficiencies' and new measures of* effective teaching. Numerous agencies are identifying mathematics courses as a stumbling block for success in undergraduate programs leading to a STEM degree. Increasing numbers of students coming to colleges and universities seek STEM careers that require postsecondary mathematics, yet many of these are poorly prepared. There is much demand to make mathematics education directly relevant to STEM careers."

"We call upon all mathematical scientists in academia to review their focus on postsecondary mathematics education. We challenge department chairs to incentivize innovation for the sake of their students and the health of our discipline. We encourage mathematics faculty to reach out to colleagues in mathematics-intensive disciplines in order to heighten the relevance of their courses to the careers of their students. And we urge departments as a whole to investigate with an open mind new teaching methodologies and technologies, keeping in mind the need to retain and motivate students."

SOURCE: David M. Bressoud, Eric M. Friedlander and C. David Levermore, "Meeting the Challenges of Postsecondary Education in the Mathematical Sciences," *MAA Focus*, February-March 2014

[4] Remarks at Transforming Postsecondary Education in Mathematics Panel, Joint Mathematics Meeting, Baltimore, Maryland, January 17, 2014

- This is the time to identify and introduce innovative teaching and learning strategies, using new instructional delivery options, new technologies and new tools to support student learning.
- Today's online education opportunities are growing rapidly because of advances in cognitive science (i.e., we know a lot more about what imprints information on the brain), the availability of powerful software and the highly interactive, ubiquitous Internet.
- New teaching and learning strategies are urgently needed for adult learners for whom mathematics can be an insurmountable obstacle to earning a highly valued postsecondary degree or certificate.

These issues are not unique to Ohio and there is much we can learn from work in other states, just as we can find solutions in the creative practices of mathematics departments in some of our own USO institutions. Instead of working in isolation, we can learn and benefit from those who got an early start. We can borrow and improve on their best and promising practices.

In this way, Ohio can make significant changes – we can lead the way – in promoting mathematics education practices that encourage young people and adults to learn and to experience what learning entails.

Four tectonic plate shifts: Forces shaping and reshaping undergraduate mathematics education in the U.S.

Four gigantic forces are shaping and reshaping the everyday life of postsecondary institutions' mathematics departments – and they are determining the direction that reform initiatives are taking in universities and colleges across the nation today.

(1) Changes in the study of mathematics. This is a glorious time for the study of mathematics. The opening years of the 21st century have been remarkable for the mathematical sciences. The list of exciting accomplishments includes "surprising proofs of the long-standing Poincaré conjecture and the 'fundamental lemma'; progress in quantifying the uncertainties in complex models; new methods for modeling and analyzing complex systems such as social networks and for extracting knowledge from massive amounts of data from biology, astronomy, the Internet, and elsewhere."* For the non-mathematics world, these and other achievements can be seen in Pixar movies, hospital medical imaging and secure credit card transactions – all revolutionized by the strength and achievement of modern mathematics.

(2) Structural forces that are reshaping higher education. Perhaps the most powerful structural change is states' shift from *enrollment* to *completion* as the driver in higher education funding. Almost all states have started in this direction with Ohio seen as one of the nation's leaders in performance funding. A second change is reflected in the growing activism of state executives, legislators and private foundations in curricular matters. With a focus on redefining programs of study and majors, and on setting performance benchmarks, these non-campus players have interjected themselves into matters long thought to be the responsibility of faculty and administrators. They are making deep sea changes in the landscape that affects public colleges and universities. And the spotlight often is on mathematics programs where remediation is so often needed and undergraduate courses typically have the highest failure rates.

(3) Structural forces in K-12 education. With the anticipated implementation of the state's New Learning Standards for K-12 students, Ohio high schools are preparing to shift the meaning of a secondary diploma from a document that verifies the completion of a set of courses to a certificate of college and workplace readiness. As such, it *will* create new demands for secondary and postsecondary curriculum alignment, and it will require changes in the way decisions are made (i.e., mechanisms for shared responsibility in this area). In addition, structural changes are being reflected in a growing bifurcation in high school mathematics outcomes (i.e., many graduates are being highly prepared with more students than ever before taking calculus, even as a much larger number of students are leaving high school underprepared for college mathematics).

(4) Fundamental and basic changes in the American economy. The data are clear: more jobs today require postsecondary education than ever before, and a growing number of jobs in the 21st century's technology-driven economy call for more and different mathematics knowledge and skills.** Yet, the most significant structural changes are being seen in mathematics capability as a determinant of upward mobility. Before 2000, most workers stayed in a single industry and moved up throughout their careers. But today, upward mobility is more frequently achieved by moving across industries. Mathematics achievement is a key correlate of this upward mobility because employers often see success in mathematics as a proxy for problem-solving ability.

These are four fundamental shifts to which the mathematics community's core mainstream is responding by modernizing undergraduate mathematics programs, reassessing gateway courses and searching for ways to remove the barriers to college completion – looking outward and building new relationships with other disciplines and increasing the productivity of its own programs.

*National Research Council. *The Mathematical Sciences in 2025.* Washington, D.C.: The National Academies Press, 2013, p. 2

**See, for example, Georgetown University Center on Education and the Workforce, *Help Wanted: Projections of Jobs and Education Requirements Through 2018*

The discussion of tectonic plate shifts is adapted from Dr. Uri Treisman's presentation to the chairpersons of 36 USO mathematics departments, January 9, 2014..

About the Ohio Mathematics Initiative

The Ohio Board of Regents' charge to the Ohio Mathematics Steering Committee flowed from discussions with institutional and state education policy leaders that began early in 2013 about postsecondary mathematics education in Ohio. These discussions exposed the concerns of mathematics faculty who were working on transfer issues at the state level with the current criteria and processes for mathematics course transfer from one campus to another – a serious matter given the increase in the number of students starting in community colleges and wanting to transfer to one of the state's four-year public universities. They also revealed a growing recognition that the state's adoption of the NLS for mathematics necessitated a rethinking of Ohio's postsecondary entry-level courses and of the pathways that flow from these courses for both mathematics majors and non-majors.

On May 8, 2013, these conversations culminated in an Ohio Mathematics Summit, a meeting of mathematics faculty from all 36 USO campuses, which explored:

- policies that were impacting mathematics education in the state's two- and four-year postsecondary institutions;
- student retention issues confronting institutions across the state;
- concerns about the OTM's guidelines for mathematics, statistics and logic; and
- the effectiveness of quantitative pathways for STEM and non-STEM postsecondary majors.

Following the Summit, it was proposed that a steering committee of mathematics experts be formed to study national trends, current initiatives and available statewide and national data, and subsequently to make recommendations for future mathematics curricula in Ohio. In addition, it was proposed that the steering committee develop expectations and processes that result in each two- and four-year public campus offering pathways in mathematics that yield increased success for students in the study of mathematics, a higher percentage of students completing degree programs and effective transferability of credits for students moving from one institution to another.

One of the Steering Committee's first acts was to retain, through a contract with the OBR, the services of Dr. Uri Treisman, executive director, Ms. Jenna Cullinane, higher education policy and strategy lead, and the Charles A. Dana Center at the University of Texas to provide expertise and guidance through a series of six monthly meetings, the last of which would include a January 2014 session with the chairpersons of the mathematics departments at all USO institutions.

Beginning in July 2013, the Steering Committee identified and structured its meetings around five "Essential Components" of the work required to meet the charge given to it by the Regents:

1. Develop high quality entry-level courses and pathways connected to coherent programs of study for students majoring in (a) mathematics, (b) other mathematics-intensive majors, and (c) majors that are not mathematics-intensive.
2. Develop transfer policies and processes that provide for effective transfer of course credits and also encourage course innovation on the campuses.
3. Support constructive engagement of mathematics chairpersons and faculty within campus communities and across campuses to shape curricular policy, to improve instruction, and to bolster student support and advising.
4. Develop high quality measures for improving mathematics course offerings and instruction; collect, analyze and share relevant data.

5. Improve successful transition from high school to college by aligning higher education mathematics content and instruction with K-12 content and practice standards.

Based on these five essential components, the Steering Committee's recommended actions provide a blueprint for transforming entry-level mathematics education by giving a broad spectrum of learners clear pathways for gaining the skills and knowledge necessary for productive and satisfying performance in the 21st century economy, and by facilitating easy credit transfer and accelerated student mobility that are the cornerstones of the USO.

Mathematics is a dynamic field that continues to evolve, which means the task of shaping postsecondary programs is never done. So the question committee members continually sought to answer was, "What's best for this time." As committee chairperson Joan Leitzel told her colleagues, "It's one thing to step back, analyze a complex situation and recommend ways for moving ahead. It's quite another to implement those recommendations. So the real work of change must be done on our campuses, with the support and bold action of department chairpersons and institutional leaders."

# # #

The Ohio Higher Education Mathematics Steering Committee was comprised of 12 mathematics faculty from Ohio public institutions of higher education, five ex-officio members and Ohio Board of Regents staff. It was chaired by Dr. Joan Leitzel, Professor Emeritus of Mathematics at The Ohio State University and former President of the University of New Hampshire. Dr. Leitzel has led a distinguished career in education that includes serving on the board of directors of the National Association of State Universities and Land Grant Colleges (now APLU) and chairing the board of the American Association for Higher Education. She also chaired the Mathematical Sciences Education Board at the National Research Council from 2000-2004 and is past-chair of the Conference Board of the Mathematical Sciences.

The full steering committee membership was:

Steering Committee Members

Linda Chamblin
Associate Professor of Mathematics
Southern State Community College

Patrick Dowling
Professor and Chair, Mathematics
Miami University

Joan Leitzel, Chair
Professor Emeritus Mathematics
The Ohio State University

Krista Maxson
Interim Associate Provost for Research and Graduate Programs and Department Chair, Mathematics
Shawnee State University

Jeff McNeal
Professor of Mathematics

Ricardo Moena
Associate Professor and Director of Entry-Level Mathematics
University of Cincinnati

Rodney Null
Professor of Mathematics
Rhodes State College

Carl Stitz
Professor of Mathematics
Lakeland Community College

Andrew Tonge
Professor and Chair, Mathematics
Kent State University

Michelle Younker
Associate Professor of Mathematics

The Ohio State University

David Meel
Professor and Interim Chair, Mathematics
Bowling Green State University

Terra State Community College

Jeff Zeager
Professor of Mathematics
Lorain County Community College

Ex-Officio Members

Cathy Chudzinski
Professor of Biology
Terra Community College

Bruce Johnson
President
Inter-University Council of Ohio

Brian Roget
Associate Director, Curriculum and Assessment,
Ohio Department of Education

Mike Snider
Project Coordinator
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Hideo Tsuchida
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Brett Visger
Associate Vice Chancellor, Institutional Collaboration and Completion
Ohio Board of Regents

Rebecca Watts
Associate Vice Chancellor, P-16 Initiatives
Ohio Board of Regents

Developing high-quality entry-level courses and pathways

As members of the Steering Committee prepared to wrap up their work, a *New York Times* editorial asked, "Who says math has to be boring?"[5] The editorial acknowledged that most students in the U.S. are bored by math, science and engineering. It read, "They buy smartphones and tablets by the millions, but don't pursue the skills necessary to build them. Engineers and physicists are often portrayed as clueless geeks on television, and despite the high pay and the importance of such jobs to the country's future, the vast majority of high school graduates don't want to go after them."

Why? Noting that many students have been turned off to mathematics and science as they moved from kindergarten to high school, the editorial asserted that the American system of teaching these subjects is broken. It pointed specifically to high schools that continue to offer only mathematics and science pathways that assume that students will pursue these subjects in college."[6]

The problem goes deeper than this. Students who successfully navigate the secondary mathematics curriculum too often find themselves enrolled in a postsecondary college algebra course – the prescribed gateway course – that is designed to prepare them for calculus and focuses on mathematics that may not be useful in subsequent courses in their program. Without being given an opportunity to take a course that is linked in any way to their intended area of study or to another area of interest, large numbers of these students never complete the entry-level course.

STRATEGY #1:

Develop high-quality entry-level courses and pathways connected to coherent programs of study for students majoring in (1) mathematics, (2) other mathematics-intensive majors, and (3) majors that are not mathematics intensive.

Recognizing these concerns, the Steering Committee examined a number of innovative approaches to improving student success in entry-level courses, giving special attention to those that have connected learning pathways to coherent programs of study for students majoring in mathematics, other mathematics-intensive disciplines and majors that are not mathematics intensive. It also searched for promising strategies for supporting postsecondary students who are not adequately prepared to succeed in gateway mathematics courses.

Based on its review of the best and promising practices, the Steering Committee offers two recommendations:

Issue 1.1

College algebra – the current gateway course in most mathematics departments -- is designed to prepare students for calculus and a subsequent series of mathematics courses. Yet, very few college algebra students intend to enroll or ever do enroll in a calculus course.

Research suggests that contextualizing mathematics promotes increased student engagement and improves completion rates. This is particularly important for students who expect to major in a mathematics-intensive discipline, but also has relevance for students who expect to major in the social sciences, business or other fields.

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[5] Editorial, "Who Says Math Has to Be Boring?" *The New York Times*, December 7, 2013

[6] Ibid.

This points to the need for alternative entry-level mathematics courses (e.g., quantitative reasoning, modeling and elementary statistics) that are connected to students' postsecondary objectives. It also calls for the re-tooling of traditional delivery methods in existing gateway courses and for professional development for instructors. These changes will make the study of mathematics more relevant and inviting for a broader range of students. And it will improve student success and college completion rates.

- ***Recommendation 1.1: Improve student success in entry-level courses by aligning mathematics to academic programs of study and by improving instructional delivery mechanisms***

USO institutions should begin by developing and offering entry-level mathematics courses, or by redesigning existing courses, to serve the needs of students in clusters of academic programs (e.g. the social sciences, business and finance, allied health and other STEM disciplines). In particular, departments should remove college algebra as the ***default*** mathematics course for non-STEM majors.

In addition, mathematics departments should ensure that modern course instructional materials and delivery technologies -- reflecting best and promising practices that support teaching and learning – are used in their entry-level courses. Ideas and resources should be shared through a mathematics chairpersons network.

Issue 1.2

Institutional data tell us that students with low ACT scores have a low probability of success in entry-level courses. For these and other students unprepared for college-level work, remediation has long been the traditional answer.

Yet, there is growing evidence that for far too many students, postsecondary remedial courses are a dead end. It is a serious problem because, as the OBR has reported, 40 percent of students who graduated from an Ohio high school in 2012 and then enrolled in a public two- or four-year college or university had to take remedial courses in mathematics or English prior to enrolling in a credit-bearing course.[7]

If traditional remediation isn't the answer, what is? An alternative solution is a ***co-requisite strategy*** for improving remedial education, and ultimately, college completion rates. With the co-requisite course model, students who demonstrate a few academic deficiencies are placed immediately into entry-level, credit-bearing college courses ***and*** co-requisite support courses. For these students, co-requisite placement is the default for remediation with the length and structure of co-requisite support courses varied depending on the seriousness of a student's academic weaknesses.

- ***Recommendation 1.2: Develop, implement and evaluate co-requisite strategies to support underprepared students***

All USO institutions should integrate supplemental support (including supplemental instruction, intrusive advising and a high degree of programmatic coordination) directly with credit-bearing courses. Gaps in knowledge should be addressed in a "just-in-time" manner.

[7] Ohio Board of Regents, *2013 Status of Ohio Graduates Remediation Report by District*

A small statewide working group should begin by reviewing co-requisite models in Ohio and other states and identifying a small number of recommended models for use by USO institutions. Promising examples of strategies that support alternative entry-level courses include Quantway/Statway, New Mathways Project statistics, quantitative reasoning and STEM-prep pathways, and co-requisite models such as Austin Peay University.

The statewide group should develop and disseminate co-requisite curricular materials to provide just-in-time support to students and resources for advisors placing students in co-requisites. College algebra, pre-calculus, quantitative reasoning, elementary statistics and modeling should be the focus of co-requisite materials development. The group should provide information about the number and type of credits offered, staffing, target student populations, pedagogical strategies, faculty professional development and financing.

Promoting the effective transfer of course credits

Easy credit transfer and accelerated student mobility are the cornerstones of the USO. They help all learners – newly minted high school graduates as well as returning adults – earn the postsecondary credentials that create economic opportunity, drive economic growth and enhance quality of life. Within this context, giving students a clear pathway for gaining the skills and knowledge necessary for productive and satisfying performance in today's economy could hardly be more critical to our collective future.

The state's commitment to easing the way in which students can move to and from public colleges and universities, transfer credits within the system and apply those credits toward the requirements for a postsecondary education degree or certificate is reflected in the OBR's *Ohio Articulation and Transfer Policy:*

> "The Ohio General Assembly, the Ohio Board of Regents, Ohio's universities and community and technical colleges support multiple educational pathways to meet the full spectrum of student needs and educational aspirations. Life circumstances often necessitate the transfer of students and credit hours from one college or university to another. It follows that an improved process for transfer student mobility will increase both student satisfaction and degree completion. Sound public policy must include provisions to maximize credit for prior learning and equitable treatment for transfer students. Inter-institutional cooperation is essential to facilitate transfer and sustain a high level of academic integrity in the system."

STRATEGY #2:

Develop transfer policies and processes that foster effective transfer of course credits while encouraging course innovation on all public campuses.

The OTM, the Transfer Assurance Guides (TAGs) and the state's Articulation and Transfer Advisory Council are concrete examples of this commitment to expanding student mobility and credit transfer options. Yet, in recent months, a growing number of individuals and institutions have voiced concerns about the OTM's processes and criteria for mathematics course and credit transfer.

For this reason, the Steering Committee reviewed current transfer models and processes for obtaining transfer approval, with an emphasis on ensuring the applicability of new and existing courses to majors and programs of study, and on providing uniform standards while still accommodating course innovation. The Committee debated the relative value of TAGs based on a specific set of topics and techniques, on the one hand, and student learning outcomes, on the other. It also examined the issue of prerequisite courses and the processes for approving courses and credits.

Recognizing the heightened importance of progressive, flexible and user-friendly policies and procedures for articulation and transfer, the Steering Committee offers three recommendations:

Issue 2.1

The current practice of requiring OTM course criteria and processes to include a set of specific topics and techniques is restrictive and stifles innovation. Faculty panels are forced to reject courses from OTM consideration because course descriptions do not contain the entire prescribed list of topics, even when the course may accomplish the goal of preparing the student to continue learning. Additionally,

entry-level course content is changing as are diagnostics, personalized instruction methods and available technologies – all of which are impeded by current processes and transfer criteria.

- ***Recommendation 2.1: Redesign OTM course criteria and processes to focus on student learning outcomes***

Instead of focusing on prerequisites and topic lists, OTM course submissions should target the big ideas a student knows, describe desired learning outcomes and list possible evidence criteria. The emphasis should be on the degree of readiness for subsequent mathematics courses or readiness for quantitative reasoning in other courses or disciplines.

This change should be an immediate priority because most four-year and some two-year institutions already have, for example, different versions of calculus and college algebra. Building upon and expanding the current outcome-based approval process will make it possible to include all course variations, which, it is widely agreed, will accomplish the same purpose.

Finally, the Steering Committee believes that with the completion of its study and the submission of its final report, a comprehensive implementation plan should be prepared, with timelines for the periodic review of OTM guidelines and learning outcomes already in place and procedures for expanding the current offering of learning outcomes to include new mathematics courses accepted into the OTM.

Issue 2.2

Generally speaking, entry-level course prerequisites should be those that are needed to provide a foundation for student success in that course. The course description and learning outcomes of a mathematics course should, therefore, identify the prerequisite level of mathematical literacy, skills and knowledge necessary for successful completion of the course. We know, however, that the content in Intermediate Algebra courses, for example, while generally required to master the content of algebra-based STEM courses, is ***not*** required for most non-STEM college-level mathematics courses.

Consequently, there is a need to broaden prerequisites for certain mathematics courses, which would allow OTM panels to include a wider variety of acceptable entry-level courses than presently are eligible for transfer. Colleges and universities also need flexibility to determine the amount of time allocated to entry-level courses based on their entry requirements and pedagogical practices.

- ***Recommendation 2.2: Increase departmental flexibility in determining prerequisite courses and credit hour requirements for OTM courses***

College and university mathematics departments should be permitted to broaden acceptable alternatives to demonstrate student readiness for different entry-level mathematics courses based on institutional data and backward-mapping of skills. OTM should remove Intermediate Algebra as the sole prerequisite for college mathematics readiness and develop guidelines for new prerequisite courses to ensure their transferability across institutions. And the Ohio Articulation and Transfer Council should remove the credit hour requirements for courses accepted in the OTM.

Issue 2.3

Inconsistencies exist among state institutions regarding what does and what does not represent college-level mathematics. Well-defined criteria for college-level courses will enhance the transferability of credits. There also is a related need to establish standards for the development of alternative pathways, especially non-STEM courses that do not require Intermediate Algebra.

➢ *Recommendation 2.3: Define what distinguishes a course as "college-level"*

Ohio's system of public higher education institutions, led by the OTM and TAG mathematics panels, or a subcommittee thereof, should establish criteria for distinguishing college-level mathematics courses from remedial or developmental courses. For example, college-level mathematics courses should build on and extend, not duplicate, Ohio's NLS.

Building an Ohio mathematics community

Change demands leadership. When that change involves complex issues and requires concerted activities by individuals, organizations and systems that lack a strong history of collective action, that demand is especially strong.

Early in its deliberations, the Steering Committee recognized the emerging complexity of its transformational agenda. So it began to search for ways to overcome the debilitating consequences of that complexity.

The Steering Committee's solution was building an Ohio mathematics community capable of leading change by helping others see the need for it, ensuring that as many stakeholders as possible (both on and off campus) understand and accept the proposed change strategy, encouraging and enabling those with responsibility for making changes, reinvigorating the process through the passage of time, and incorporating change into the culture of all USO organizations and their partners.

STRATEGY #3:

Support constructive engagement of mathematics chairpersons and faculty within campus communities and across campuses to shape curricular policy, improve instruction and bolster student support and advising.

To build that kind of leadership community, the Steering Committee offers three recommendations:

Issue 3.1

Effective leaders help others assess and find collective value and commitment to new ways. They look for ways to address the concerns of naysayers and doubters. They understand that there are no shortcuts to transformation. And they work with others in leadership positions to drive the day-to-day work that needs to be done.

In many respects, department chairpersons are well-positioned to play these roles. Yet, the Steering Committee discovered that for those who chair USO institutions' mathematics departments, there is no infrastructure for timely, meaningful cross-institution communication about matters of common concern, which might include but not be limited to dual enrollment programs, Ohio's NLS, K-12 assessments that build pathways to college and career readiness and remediation-free standards.

➢ *Recommendation 3.1: Establish a statewide network of mathematics chairpersons*

A network of mathematics chairpersons from all USO colleges and universities should be formed to establish in-person and virtual communication structures that improve understanding of and engagement in statewide issues relating to postsecondary mathematics education. Network members should meet regularly and be charged with (a) communicating information about issues to colleagues in their institutions; and (b) exchanging evidence-based information and reviewing evaluation data linked to specific initiatives or policies, including dual enrollment.

The OBR in partnership with USO institutions should form a network of mathematics chairpersons from all USO institutions with the responsibilities outlined above. The network should be convened as soon as practical to ensure the interest and support expressed at the chairpersons' January 2014 meeting are maintained.

Issue 3.2

Faculty and staff who have regular, direct interaction with students – and to whom students look for guidance – need information about both institutional and state-level policies and practices affecting mathematics instruction, alternative mathematics pathways and innovative mathematics programs. They also require up-to-date knowledge about how the mathematical sciences are being used in other disciplines – and about what faculty in those fields expect of their students with respect to quantitative knowledge and skills. Too often, this information is not readily available and students' opportunities for success can be compromised.

- ***Recommendation 3.2: Improve communication among mathematics faculty and stakeholders across institutions***

The OBR should support the building of an Ohio mathematics community by organizing a series of regional and statewide conversations involving mathematics faculty at all USO institutions. It also should explore other ways to get information on a continuing basis about statewide policies and institutional practices to mathematics faculty and advisors.

At the same time, USO mathematics chairpersons should support the building of campus-level communities by launching structured conversations with faculty, advisors and program leaders from other departments/divisions that require mathematics with the goal of strengthening relationships and exploring a range of curriculum and instructional issues.

Issue 3.3

Professional association meetings offer many professional development opportunities and cross-institutional communication. Yet, participation at these meetings often is not high and conversations/presentations about curriculum reform, the alignment of secondary and postsecondary mathematics courses, innovative teaching strategies and alternative learning pathways fail to reach large numbers of faculty members.

- ***Recommendation 3.3: Encourage and promote mathematics faculty participation in meetings of professional groups***

Members of the mathematics chairpersons network should leverage the existing and emerging communication infrastructure so faculty can engage in ongoing scholarly discourse about best practices and issues relating to mathematics education.

The mathematics chairpersons network and the OBR should collectively ensure mathematics faculty and staff – including graduate teaching assistants and advisors – receive appropriate professional development. The chairpersons network should explore ways to increase faculty participation at professional association meetings. In addition, it should work with mathematics professional associations' leaders in the state to ensure that their meeting agendas and professional development offerings feature discussions about best practices and issues relating to mathematics education.

Collecting, analyzing and sharing relevant data

Information overload often can be a serious challenge. Public school systems, for example, have been collecting massive amounts of data – from attendance and behavior records to indicators of students' classroom performance – for decades. This is not unlike the situation in corporate America where organizations are swimming, if not drowning, in waves of data, brought on largely by increasingly sophisticated computer tracking of production levels, sales, suppliers and customers.

From classrooms to corporate boardrooms, there is a growing realization that this data explosion actually is an enormous opportunity. For K-12 educators, much of the current focus on data tracks to the passage of the No Child Left Behind (NCLB) Act, with its emphasis on raising student achievement across all socioeconomic levels and improving the performance of "low performing" schools. With recent advances in technology, many forward-thinking district leaders have discovered that the value of data goes far beyond NCLB reporting requirements. They are using data-driven decision making techniques not only to analyze student achievement, but also to improve curriculum and teacher quality, narrow achievement gaps among student subgroups, share best practices among schools and districts, promote parental engagement in the education process and more.

> ***STRATEGY #4:***
>
> Develop high-quality measures for improving mathematics course offerings and instruction; and collect, analyze and share relevant data.

Today, data gathering and assimilation vary widely among USO institutions' mathematics programs, and the kinds of data collected differ greatly from institution to institution. Moreover, institutions' data sets are rarely shared. Consequently, it is not possible for members of Ohio's postsecondary mathematics community to think in terms of data-driven decision making without extensive planning and agreement about what will be collected, how data will be analyzed and how results will be shared and used.

Convinced that the analysis and sharing of program data can lead to improved course offerings, instruction and student success, the Steering Committee offers one recommendation.

Issue 4.1

Not all mathematics departments collect objective, comparable data to determine whether offered courses are effective and appropriate for students – both mathematics majors and non-majors – and for other departments/disciplines whose students are expected to acquire advanced quantitative skills. In addition, the OBR lacks a centralized data collection system to evaluate either student performance or course effectiveness.

- ***Recommendation 4.1: Develop quality measures for improving student success in mathematics; then collect, analyze and share relevant data***

The OBR should work collaboratively with USO institutions – and particularly the chairpersons of their mathematics departments – to develop a common protocol for collecting, analyzing and reporting data relating to student success and program effectiveness. Among the measures to be considered in establishing this protocol should be: (1) students' course grades; (2) students' success in subsequent mathematics courses or program course(s) for which the mathematics course is a prerequisite; (3) students' persistence to degree or certificate completion; and (4) comprehensive final exams along with samples of student work at various levels of performance. Other data gathered should focus on factors that likely contribute to student success, such as when a mathematics course is taken, last date

of attendance, institutional and student demographics and location of the course (especially for dual enrollment).

Once data have been reported to the state, the OBR should prepare a thorough analysis that should be shared with the mathematics chairpersons network. Analysis should focus on course grades for entry-level mathematics courses to determine norms, highlight areas of concern, and identify exemplary programs, as well as success in subsequent mathematics courses or program course(s) for which the mathematics course is a prerequisite. The OTM and TAG panels should regularly review the analysis.

Aligning secondary and postsecondary mathematics content and instruction

In Ohio and across the nation, much has been written about the "talent gap"– that is, the dual recognition that (a) the vast majority (60 percent or more) of jobs that will be available over the next decade will require some postsecondary education, and (b) the harsh reality that in Ohio, for example, just 36 percent of working-age adults have an Associate degree or higher.[8]

This is an enormous gap. And the stakes if we fail to close it amount to nothing less than our collective economic future – in particular, our ability to compete successfully for business investment and jobs that drive growth, create opportunity and enhance quality of life.

Closing Ohio's talent gap will require a Herculean effort. It also will require acknowledging that one of the major contributors to the talent gap is another kind of gap – an "expectations gap." Far too many young people are graduating from our high schools without having acquired the knowledge and skills they need to succeed in postsecondary education and careers.

This tells us, in dramatic fashion, that there clearly is a gap between what high schools are teaching (and what they believe is important for college readiness and success) and, on the other hand, what postsecondary educators expect of students in entry-level courses.

This lack of alignment undermines student success, hindering the critical transition from high school to college and careers. To improve student success in college-level mathematics courses, Ohio must better align postsecondary expectations and high school practice. And that will require new levels of collaboration and communication between high schools and postsecondary institutions.

STRATEGY #5:

Improve student success in college-level mathematics courses by aligning postsecondary expectations and high school practice.

Ohio's implementation of its NLS in 2014-2015 may provide a timely and compelling nudge in that direction. Designed to ensure that students graduating from high school are prepared to succeed in credit-bearing, entry-level courses in two- and four-year colleges and universities, or to enter the workforce, the NLS present an ideal platform on which high school and postsecondary educators can come together to understand each other's worlds and cultures, and to align expectations in a way that will provide students with clear, seamless pathways to success – in high school, in postsecondary education and in careers.

Recognizing this opportunity to close this expectations gap, the Steering Committee offers two final recommendations:

Issue 5.1

With the implementation of the new NLS, the gap between high schools' mathematics performance standards and the expectations of USO institution's gateway mathematics courses will be narrowed – some say substantially. Ideally, new secondary standards will give mathematics education greater focus and, potentially, make more coherent the relationships between the K-12 and higher education sectors.

[8] Lumina Foundation, *A Stronger Nation through Higher Education*, March 2012

Yet, changing secondary standards – and even implementing Ohio's College Credit Plus program – will not, by themselves, produce alignment. That kind of coherence will only be achieved when faculty and administrators (particularly those with curriculum responsibilities) on both sides of the education "divide" understand higher education's expectations for entry-level mathematics courses ***and*** secondary education's mathematics practice standards. This understanding and appreciation are incomplete today.

In the Steering Committee's view, what is needed is a series of actions that clarify for secondary faculty higher education's expectations for what students should know and be able to do in entry-level mathematics courses, while fully engaging university and college faculty in the implementation of the NLS.

Nothing less will work. Traditional notions of collaboration are needed, but they are not enough. Educators in both sectors must be ***encouraged and enabled*** to make alignment a priority through their greater acquaintance and hands-on experience with each other's expectations, curriculum and practice applications.

➢ *Recommendation 5.1: Strengthen collaboration and communication between K-12 and higher education on mathematics curriculum and instruction*

To help close the gap between high school exit requirements and expectations for mathematics and college/university entrance requirements and expectations, the Ohio Department of Education (ODE) and the OBR should organize a series of regional meetings to:

- Engage high school and college/university mathematics faculty in the roll-out of Ohio's new dual-enrollment initiative, College Credit Plus
- Familiarize college faculty about Ohio's NLS
- Familiarize faculty from both education sectors about the OTM

In particular, mathematics faculty on college and university campuses should take a leadership role in determining courses to be offered for the College Credit Plus program and in ensuring high-quality professional learning opportunities for participating instructors.

But talking is not enough and getting faculty engaged in ***their own*** high schools or postsecondary institutions will not achieve the alignment that is so urgently needed. So the OBR and all USO institutions should go beyond giving mathematics faculty greater acquaintance with college preparedness issues. They should work together to make this both an institutional priority and an opportunity for mathematics faculty to engage as full partners in the redesign of an aligned secondary mathematics curriculum and instructional practices.

The OBR should be responsible for convening a small group of postsecondary mathematics faculty to conduct a national scan of best and promising practices designed to align secondary and postsecondary content and instruction. In addition, the OBR should provide needed support services and should direct group members to focus on practices at both the statewide and institutional levels.

The scan should be followed by a series of regional meetings and workshops for high school and postsecondary mathematics faculty. Co-sponsored by the OBR and ODE, these sessions should be designed to engage both groups in the roll-out of College Credit Plus, educate college faculty about Ohio's NLS, and deepen secondary and postsecondary faculty members' understanding of the OTM. These regional discussions should not take place until the Ohio General Assembly approves a final version of the College Credit Plus program.

The regional meetings and workshops should be used as the launching point for an ongoing conversation among secondary and postsecondary mathematics faculty, as well as state education policy leaders, about ways to (a) align K-12 and higher education curricula (e.g., dual-enrollment courses, developmental courses, bridge courses and entry-level postsecondary courses); (b) align high school-to-college policies, including more targeted college readiness supports to help students make the transition; (c) prepare new and existing mathematics teachers to work in an effectively aligned environment; and (d) create a continuing infrastructure for aligned curriculum planning and action, as well as ways to encourage and provide incentives to mathematics faculty to engage in this work.

Issue 5.2

Transitioning to the new secondary standards for mathematics as well as a new system of gateway postsecondary mathematics courses and support services will not be easy, particularly in an environment that values alignment. It will demand changes in long-established high school and college advising programs, because dramatic improvements in student success will not be achieved without intensive support for advisors.

The assessment criteria used to place students in available gateway courses will need to be recalibrated and advisors/counselors in both sectors will need tools and knowledge to make appropriate placements and to provide students with the support services that will most likely lead to success.

- ***Recommendation 5.2: Share best practices and begin a consultation through which all USO institutions as well as faculty and advisors/counselors from Ohio high schools explore (a) new approaches to the placement of entering postsecondary students in mathematics courses, and (b) implementation of Ohio's remediation-free standards***

In cooperation with the ODE, the OBR should organize three targeted initiatives:

1. A Student Success Summit, with participation from college and high school mathematics faculty and advisors/counselors, to examine exemplary assessment and placement practices already being used in Ohio – and to explore other possible practices
2. A process for gathering and sharing data from the implementation of the state's new remediation-free standards, and for identifying best practices in this area
3. An assessment of institutional strategies' impact on the success of students just above and below the college-level cutoff – that is, to determine empirically the success rates of students near the 22 ACT-score cutoff in mathematics course pathways appropriate to the full array of academic majors

Supporting student success

The Ohio Mathematics Steering Committee has proposed a substantial number of changes in mathematics education – a more robust set of entry-level course options for undergraduate students with pathways connected to coherent programs of study; new transfer policies and processes that provide for effective transfer of course credits while encouraging course innovation on USO campuses; mathematics chairpersons and faculty engaged across campuses to shape curricular policy, improve instruction and bolster student support services; greater use of data to improve mathematics course offerings and instruction; and better alignment of higher education mathematics content and instruction with K-12 content and practice standards.

From the beginning, the Steering Committee tried to frame recommendations that would fit together as an integrated whole – and that would make sense to the students who will benefit from them, the college faculty and administrators who must carry them out and the state education policy makers who are increasingly focused on the productivity of postsecondary programs and practices. Steering Committee members believe that they have succeeded in doing this. So, they caution USO campuses and state education policy makers against implementing these recommendations in a piecemeal fashion, or against viewing them as a menu from which to pick and choose without regard to the impact such selections might have on the effectiveness of our proposed changes.

It is clear that most of the responsibility for implementing these recommendations will fall on mathematics department chairpersons and their colleagues in USO institutions across the state. But they will not be working alone. They will have the support of an emerging statewide "mathematics community," developed largely through the chairpersons network. In addition, they will be working in partnership with administrators on their own campuses and the OBR, which will assist, at least initially, by facilitating the development of the mathematics chairpersons network. The OBR also will:

- help USO campuses as they rethink and reshape their entry-level mathematics courses;
- assist in the redesign of OTM course criteria and processes to focus on student learning outcomes;
- provide support in collecting, assimilating and analyzing course- and student-level data that can be used to assess, and ultimately improve, campuses mathematics course offerings'
- lead efforts to identify and secure grants and the foundation funding needed to fully implement these changes at the campus and statewide levels; and
- work collaboratively with the ODE to promote improved alignment between secondary and postsecondary mathematics content and instruction, and support implementation of both College Credit Plus and the state's new remediation-free standards.

None of this will be easy. It will require time and resources. It will demand serious work at the departmental, institutional and statewide levels. Still, now is the time to begin – to go forward with the knowledge that the mathematical sciences are the providers of broad quantitative literacy, the source of upward mobility for workers in many industries, and the shapers of those who, in the next generation, will lead us in an increasingly data-driven, technological, global society.

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