CHAPTER 3 - A Faculty's Guide: Mathematics in the First Two Years

Faculty exert strong influences over student learning in mathematics and student success. In order to produce positive influences, faculty need to design a learning environment that fosters student engagement and empowers students to take ownership of their learning. Student success requires curriculum and courses that are designed to meet the needs of students, whether they are in STEM fields, or other fields, and that are aligned with the two-year college mission of career, responsible citizenry, and personal improvement. Faculty also need to use student performance to assess effectiveness and make changes needed to assure that students are proficient, not only in performing routine exercises, but in meaningful analysis, modeling and problem solving.

Faculty are responsible for the critical components which build PROWESS within a modern college environment. Faculty have primary ownership of:

- Curriculum: Sets of courses designed to provide mathematics aligned with the best thinking about content
- Course design: Each course is developed to connect that mathematics to students and their learning, including delivery methods and learning technology
- Learning environment: Instruction and assessment practices intentionally developed to support all students
- Assessment and Maintenance: Improvement methodologies applied consistently to build longterm success

These responsibilities require that every faculty member develop both content expertise and knowledge of the cognitive sciences.

Faculty also work with others in these areas:

- Procedures that assist students in initial placement into a mathematic course
- Advising students as to which mathematics course is most appropriate
- Analyzing student, course, and program data

By "faculty" we mean all faculty engaged with teaching mathematics within the first two years of college, regardless of the specific role. The responsibilities are held both individually and collectively; this chapter will focus on individual faculty and some groups of faculty. The next chapter will address responsibilities of departments and institutions.

Faculty PROWESS begins with proficiency in curriculum and instruction within mathematics. Developing this proficiency is a long-term process based on engagement with professional organizations (including AMATYC, MAA, ASA, SIAM, and others) combined with local & regional resources for faculty development.



Standards in Curriculum

The AMATYC IMPACT standards are not focused on any particular curriculum or model. However, we do endorse some design principles to assist faculty with their responsibilities. The Common Vision document provides a framework for improving the curriculum in the first two years (pgs 12-13):

- **5** Enhance students' perceptions of the beauty, vitality, and power of the mathematical sciences.
- $\begin{array}{ll} \sum & \mbox{Enhance students' understanding of mathematics as a creative endeavor.} \\ \sum & \mbox{Increase students' quantitative and logical reasoning abilities needed for informed} \end{array}$ citizenship and for the workplace.
- \sum Increase students' confidence and joy in doing mathematics and statistics \sum Improve students' ability to communicate quantitative ideas orally and in
- Improve students' ability to communicate quantitative ideas orally and in writing (and since a precursor to communication is understanding, improve students' ability to interpret information, organize material, and reflect on results).
- **Encourage students to continue taking courses in the mathematical sciences**

Based on these goals, the AMATYC IMPACT standards provide the following general goals for our curriculum in the first two years of college mathematics:

- > Faculty should have deep knowledge of recent professional work in curriculum relevant to their primary areas of responsibility (MAA CUPM ... ASA GAISE ... AMATYC IMPACT ... and so on). This expertise is just as important as the initial credential required of faculty.
- > Mathematics courses at all levels need to balance multiple approaches to reflect the status of the profession (such as symbolic and numeric methods). Computation & modeling skills using inductive reasoning should be developed concurrently with formal deductive reasoning.
- Since students will be expected to transfer what is learned in mathematics classrooms to a variety of contexts and situations, the curriculum needs to focus on reasoning at multiple levels within each mathematics course. In addition, students must be challenged to apply mathematics in a variety of problem situations. The phrase "quantitative literacy" is sometimes used to capture this goal.
- > The curriculum sequence should be designed to support the needs of students in a wide variety of college programs. In some cases, this means 'pathways' choices should be included in the curriculum in which a sequence of courses is designed to serve only students in specific programs.

The chart below captures specific standards for parts of the curriculum.

Quantitative Literacy	Developmental Mathematics	General Education
(All mathematics courses)		
Determine appropriate quantitative	Design courses and classes to	[Includes Quantitative
literacy outcomes for each	produce desired student	Reasoning, Liberal Arts
mathematics course and include	outcomes in developmental	Mathematics, Statistics and
these outcomes in course outlines	mathematics within one year	other courses]
	of college attendance, using	
Encourage students to represent and	accelerated formats for	Include writing, critical
communicate mathematical ideas	appropriate cohorts of	thinking, quantitative
using a variety of modalities	students	literacy, and logical
including numerical, graphical,		reasoning needed for an
symbolic, and verbal representations	Make decisions about content	informed citizenry
	(what to emphasize, de-	
Promote mathematics across the	emphasize, delete, or add)	Help students develop an
curriculum by initiating	based on input from other	understanding of the
collaborations with faculty with	professionals and organizations	interconnectedness of
other disciplines, promoting the	as well as in an effort to	mathematical ideas and how
integration of quantitative literacy in	provide the most appropriate	these ideas can be used to
all programs of the college, and	experience for all students	describe real-world
promoting positive attitudes by all		phenomena
faculty and students towards	Demonstrate and encourage	
mathematics	multiple problem-solving	Collaborate with faculty from
	strategies using appropriate	other disciplines to
Integrate technology into every	tools from algebra, geometry,	determine learning
mathematics course as both an aid in	and statistics	outcomes for general
computation and as a modeling tool		education mathematics
which encourages students to	Integrate technology into	courses
investigate patterns, formulate and	developmental mathematics	
test conjectures.	courses as a tool	Use data with modeling or
	to investigate and promote	statistical tools to help
Promote algebraic thinking through	understanding of mathematical	students develop better
activities which emphasize the	concepts	understandings of economic,
recognition of patterns, relations,		social or cultural issues
and functions; reinforce the	Use modern teaching methods	
importance of the acquisition of skills	including active learning and	
in manipulating algebraic expressions	technology	
Provide students with opportunities	Ensure that understanding and	
to apply a variety of problem-solving	reasoning are represented in	
strategies to solve both routine and	the majority of course and	
non-routine problems including	program learning outcomes.	
substantive and contextualized		
situations	Provide a variety of 'practice'	
	to reinforce ideas, including	
Intentionally design instruction to	blocked practice but	
neip students build strong cognitive	emphasizing mixed practice for	
schema focusing on coherence,	better learning	
connections and understanding.		

Establish partnerships with representatives from local businesses and industry to identify essential skills that students must bring to the workplace. Use their input to keep course content relevant incorporate workplace skills in the learning outcomes of the curriculum (including 'soft skills') Encourage active student learning and the development of team-building skills with term projects, collaborative projects, collaborative projects, collaborative projects, not folio, research, field investigations, or internships Use technology, throughout curricula to discover properties, to develop examine multiple perspectives, and to gain experience with the technology skills they will use for problem solving in the workplace Use data with modeling or statistical tools to help students develop better understanding of how mathematics is used a tool in other disciplines	Technical & Occupational	Teacher Preparation	Mathematics Intensive
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Standards in Course Design

The AMATYC IMPACT standards support recent work in the profession, including the Common Vision document, and add some additional frameworks for developing an effective and up-to-date course. This section deals with the macro-level choices made about courses, while the Learning Environment section deals with micro-level choices within the course.

Decisions about course design articulate how the curriculum is going to be delivered to students in ways that promote PROWESS: PRoficiency, OWnership, Engagement and Student Success. These decisions are best viewed as a joint responsibility by all faculty involved with a given course, including a joint decision on ranges of acceptable variation between sections and delivery methods.

The AMATYC IMPACT standards provide the following general goals for course design in the first two years of college mathematics:

- Effective instruction is not limited to a specific style of teaching; effective course design incorporates diverse styles within and across courses. Current work in the cognitive sciences should inform the instructional design to intentionally support students in achieving the identified student learning outcomes.
- Increasing and maintaining high levels of student engagement will contribute to building proficiency and student success.
- Providing support for students to develop a more diverse set of learning skills is more important than attempting to match students' "learning styles"; learning styles is not a stable cognitive construct, while "learning skills" has a sound research basis.
- Course materials might be traditional textbooks, e-books, or Open Educational Resources (OER); the selection of these materials should be based on criteria related to quality, effectiveness, and affordability.
- Learning technology should be included in all mathematics courses, and the use of technology should support the curricular goals and course outcomes. Mobile devices (both calculators and smart phones) need to be part of this mix of technology.
- Alternatives to the traditional semester or quarter length courses could enhance the mathematics experience for some cohorts of students. This might include co-requisite structures, fast track courses, and individualized learning.

Implied within the curriculum and course design standards is the goal of every math course contributing to helping students become better and more skilled learners. Every course design should include some attention to this goal, regardless of level of course or format of delivery.

The course design also needs to support the wide diversity of our students, both culturally and physically. (For this purpose, we include learning disabilities in the physical category of diversity.) Faculty must recognize that diversity manifests itself in a variety of ways: age, gender, ethnicity, socio-economic background, and academic preparation. Achieving PROWESS requires that colleges provide all students with both opportunities and assistance, including students with significant language differences. The course design should be based on our success goal ... each and every student will pass a given course.

The chart below captures specific standards for categories in course design.

Have high expectations of all students and cleary communicate those expectations to studentsUse 'best practices' for increasing success rates for minority studentsBe sensitive to the fact that many students are balancing family, job, and academic responsibilities; provide constructive suggestions and support in the processWhile the student population may be diverse, the educational outcomes for a course must be expected of all students.Strive to include underrepresented demographic groups in mathematicsProvide explicit expectations support in the processBe aware of and accommodate diverse student needsUse strategies shown to reduce "stereotype threat"Provide explicit expectations social media during class, homework completion, seeking assistance, etc).Collaborate with appropriate support services personnel to respond to the needs of students with disabilitiesBroaden the foci of each course beyond procedural accuracy broessExplicitly direct students to consider their own cognitive processe; develop metacognitive skillsAdvise students of the availability and appropriate use of academic support resourcesOnline or Distance Learning mathematics advisorsIndividualized formatsUtilize specific teaching strategies for different populations of students/coursesSelect technology that is accessible to student senoled in their distance learning mathematics courseMaintain high levels of faculty- student interactionDesign instruction and assessment so that individual student scept theirSelect technology that is accessible to students enrolled in their distance learning mathematics distore learning mathematics distore	Diversity of Students	Equity for Students	Learning Skills
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Learning environment

In all course designs, the learning environment is where students experience mathematics with the guidance of faculty. The details of a learning environment support the curriculum and course design so that students achieve PROWESS. The word "classroom" also refers to the learning environment, though we prefer the broader term "learning environment" to include all settings in which faculty and students interact with and learn mathematics.

The AMATYC IMPACT standards provide the following general goals for the learning environment in the first two years of college mathematics:

- The quality of the interactions in the learning environment determines the effectiveness in mastering mathematics.
- The learning environment should foster active student engagement in mathematical thinking, encourages student creativity and risk-taking, and promotes a culture that values the diverse interests and backgrounds of students.
- The learning environment should furnish students and faculty with the appropriate physical space, materials, technological resources, and support staff necessary to facilitate effective learning of mathematical concepts and skills.
- Faculty should use innovative teaching and learning strategies that incorporate technology and learning activities designed to promote active student engagement, meaningful discourse and cooperative learning.
- ➤ The learning environment should be designed to be effective in developing PROWESS, which includes increasing students' persistence, grit, and communication skills
- Other goals include: Respect diverse talents and ways of learning and teaching; use a variety of classroom activities, assignments, and assessments; encourage student-faculty contact; provide students with prompt feedback

The chart below captures specific standards for the learning environment.

Student Diversity	Factors that Influence Learning	Connect to Outside the
		Classroom
Have high expectations of all	Make mathematics accessible to all	Refer students to
students and clearly	students, being sensitive to the impact of	appropriate support
communicate those	mathematics anxiety on students and teach	services for help in
expectations to students	students to employ strategies to control,	reducing mathematics
De avera af and a construct a data	manage, and reduce student anxiety	anxiety
Be aware of and accommodate		
diverse student needs	Provide students with course information	Be involved in the design
	outlining course objectives, concepts,	of and the decision-
Collaborate with appropriate	Ideas,	making about physical
support services personnel to	and learning outcomes for their	spaces that support
respond to the needs of	mathematics course	mathematics instruction
students with disabilities	Structure the learning environment of that	Identify and recommand
Sonyo as student mentors and	structure the learning environment so that	needed technology
mathematics advisors	material and to correct prior knowledge as	needed technology
	needed in order to create cognitive	Encourage appropriate
Advise students of the	schema which are more stable and	interaction with students
availability and appropriate use	productive in future work	and between students
of academic support resources		inside and outside
of academic support resources	Advise students on the expectations of	of the classroom
Use 'best practices' for	their distance learning mathematics course	
increasing success rates for	and orient them to the distance learning	Be available outside of
minority students	environment for their course	the classroom to assist
		individual students
Strive to include	Be aware of the diverse mathematics	
underrepresented	backgrounds of their students	Provide service learning
demographic groups in		opportunities for
mathematics	Answer questions and explain material	students in your courses
	carefully and clearly, being patient.	,
Utilize specific teaching	supportive, and available to help when	Foster undergraduate
strategies for different	students are frustrated or confused	research.
populations of		
students/courses	Regularly require students to work on	
	mathematics outside the classroom. This	
Directly encourage student	will include expecting students to prepare	
motivation for all students	for class as well as to practice what is done	
	in class. Instructors will encourage these	
Be sensitive to the fact that	behaviors with timely feedback	
many students are balancing		
family, job, and academic	Use multiple categories of assessment	
responsibilities; provide	measures, including items that	
constructive suggestions and	differentiate situational, institutional, and	
support in the process.	dispositional factors.	
	Use the history of mathematics to engage	
	learning	

Instructor talk should support student engagement with the materialStructure for positive interdependence: Group interaction is necessary for successful resolution of the question or task; linking individual success and the success of the group 1Individual work should occur frequently in mathematics classroomsLecturing should be focused on building meaningful mastery of the learning outcomes, as should all methods of instruction.question or task; linking individual success and the success of the group 1Individual work should include all levels of learning (conceptual, procedural), not merely exercises that mimic recently explained procedures.Use questioning to promote student engagement and toinclude discussing solutionTechnology is a valuable tool for
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Use questioning to promoteinteraction: Group interactionsstudent engagement and toinclude discussing solutionTechnology is a valuable tool for
student engagement and to include discussing solution Technology is a valuable tool for
measure student understanding paths, important concepts, and individualizing learning, but not a
connections to prior knowledge replacement for interaction with
and facilitating words of mathematics faculty
encouragement and help when
needed 1
Structure individual
accountability: Students are held
accountable for their share of
the work in the group -
Structure social skills: Group
interaction requires
internersonal social and
collaborative skills Students
must be provided guidance in
how to effectively interact in a
small group ¹
Structure group processing:
Group members discuss
effectiveness in reaching their
goals and in working together ¹
Faculty should receive training
on the techniques and
justification for the specific
group work done (think-pair-
share, paired-board work, jig-
saw teaching, etc)

These items taken from Johnson and Johnson (1999)

Assessment and Maintenance

Assessment refers to processes that provide information on the nature and quality of learning. This feedback is critical for all three components discussed: Curriculum (called "Program" assessment here), Course Design, and Learning Environment (called "Classroom Assessment). A single assessment activity might produce information on just one component, or it might address multiple components.

In all cases, the purpose of assessment is to improve learning and build PROWESS.

The AMATYC IMPACT standards provide the following general goals for assessment in the first two years of college mathematics:

- Assessment is an ongoing process of collecting pertinent evidence that informs instructors about students' understandings of mathematical concepts, the student's proficiency with specific procedures, and the student's ability to apply various problem-solving strategies in solving both routine and non-routine problems.
- Assessment should incorporate authentic assessments, which strive to evaluate students' abilities in real-world contexts.
- Assessments should focus on analytical skills, the ability for students to integrate what they learn, have students work collaboratively, and articulate their thinking in written and oral modes.

Assessments are used at different levels ... each classroom, each course, and each program. Each level seeks to provide both measurements against an acceptable level and measurements of improvement over time. The validity and reliability of assessments should be measured and developed as part of the process – presumptions about either validity or reliability of particular assessments need to be supported by evidence.

Classroom Assessment	Course Assessment	Program Assessment
Incorporate classroom	In conjunction with other	Identify assessment tools linked to
assessment activities into the	faculty, locally and/or regionally,	desired student learning outcomes
classroom learning environment	agree upon the core student	and proceed through the
on a regular basis; learning and	learning outcomes for each	assessment implementation cycle
assessment are concurrent	mathematics course	to implement improvements
processes		
	Communicate course outcomes	Develop assessments to monitor
Provide feedback at times and in	to students at the beginning of	placement and progression in
ways that are most helpful to	the course.	sequences and pathways
student learning	Lisa course assassments to	Participato in the development
Adjust classroom activities in	measure achievement of those	and assessment of general
response to assessment	outcomes and determine	education outcomes in
information	needed improvements	mathematics
Discuss assessment results with	Use results of assessment to	Determine which of the general
students and explain how the	improve the learning	education outcomes are met
information is being used	environment during the course	when students complete a
to make instructional decisions	and in subsequent semesters	given mathematics course
Use a variety of assessment		Continually use assessment results
techniques including formative,		to evaluate program effectiveness
summative, and authentic		
assessments		
Use assessment data as a		
misconcentions and		
misunderstandings		