Ohio Department of Higher Education
25 South Front Street
Columbus, Ohio 43215
614.466.3334
ohiohighered.org/mathematics-initiative

Up2Date
Ohio Mathematics Initiative

Quantitative Reasoning Workshop

March 2-3, 2017

Background

- Quantitative Reasoning (QR) is the application of mathematics to the analysis and interpretation of real-world quantitative information, either in the context of a single discipline or across multiple disciplines. In QR courses, students learn how to analyze real-life situations in ways that allow mathematical tools to be used to generate useful solutions.
- QR is among several important 21st century intellectual skills all students should master, including analytic inquiry, critical and creative thinking, written and oral communication, information literacy, teamwork, and problem solving.
- For this reason, in December 2015 the Ohio Articulation and Transfer Network (OATN) announced endorsement of a new Ohio Transfer Module (OTM) course with learning outcomes in Quantitative Reasoning.
- The development of this new course gives students in Ohio's public colleges and universities three well-defined, faculty-developed learning pathways in mathematics – a Statistics Pathway; a Quantitative Reasoning Pathway; and a STEM Preparation Pathway – that yield increased success for students in mathematics, as well as effective transferability of credits for students moving from one institution to another.
- In March 2016, the QR Faculty Team, in collaboration with OATN, hosted a full-day QR workshop for mathematics faculty and administrators from the state's public colleges and universities. That workshop had three objectives: (1) give participants a better understanding of the basics of a QR course and effective pedagogy; (2) increase awareness of the new Ohio Transfer Module QR course learning outcomes; and (3) explore non-lecture, active learning approaches to teaching QR that promote students' use of oral and written communication, as well as group work.

Purpose of the 2017 Workshop

- The primary objective of OATN's second workshop was to help faculty design their institutions' QR courses, built around a rigorous, well-structured curriculum that is "taught" in an ***active learning*** classroom environment in which content is connected to real-life situations; and in which students engage in mathematical investigation, communication and group problem-solving.

Ohio Mathematics Initiative

Ohio | Department of Higher Education

Active learning techniques are supported by extensive research showing that students learn more rapidly, retain knowledge longer, and develop superior critical thinking skills when they are actively involved in the learning process.

An Active Learning Ice Breaker

- Following a welcome by Dr. Jack Cooley, Senior Vice President for Academic Affairs at Columbus State Community College, and a workshop overview by Ms. Michelle Younker from Owens Community College, all attendees participated in a mystery exercise.
- With "WhoDunnit?," participants were told that someone's been murdered and it's their job to solve the crime. Using a set of clues and ***active learning techniques,*** small groups sought to determine who died, where he/she died, how he/she was killed, what time the victim died, the identity of the killer, and the reason for the crime. *The purpose of this activity was to model an 'ice breaker' that actively engages students and helps them develop some of the norms of working in groups and productively engaging in problem solving.*

"Enough of the Lecturing" – Understanding the Value of Active Learning

- The workshop featured Dr. Carol Schumacher, professor of mathematics and chair of the Kenyon College faculty. A leader in active learning strategies, Dr. Schumacher led a discussion using a combined lecture format and video clips of actual classroom situations. (She "apologized" for the lecturing.)
- On active learning, Professor Schumacher cited a meta-study based on more than 200 STEM-based studies that shows the benefits for students of this instructional approach: (1) greater knowledge; (2) longer retention; and (3) better understanding. She said active learning is always a good idea, requires new classroom structures, offers a win-win situation for students and instructors, and transforms the notion of time.
- She said lectures aren't the answer to learning. For one thing, they assume that it is possible and desirable to smooth out the "messiness" of learning processes. In addition, they aren't well suited for helping students learn how to dig in and understand information on their own terms.

QR workshop faculty. From left to right: Ricardo Moena, Carol Schumacher, Aaron Altose, Jim Willis, Michelle Younker and Andrew Tonae.

- In contrast, active learning involves discovery, which:
  - Helps students through their floundering when they are "stumped."
  - Gives students a learner-centered, as opposed to an instructor-centered, environment.
  - Tells students that they "can do it."
  - Takes more time, but can be transformative.
- While Dr. Schumacher emphasized that there are a variety of approaches to active learning, all of them share some common features. For example, they all:
  - Put a priority on student-to-student communication.
  - Put an emphasis on student-centered work.

- ► Require plenty of student support, including learning guides and resource materials.
- ► Involve students working collectively.
- ► Turn the instructor into a coach.
- ► Focus on inquiry-based learning, in which the instructor supports the students' mathematical development and learning.
- ► Produce higher levels of student satisfaction, if delivered effectively.

- There are things about active learning that make it hard. It takes tremendous patience – a willingness on the instructor's part to give students enough time. Also, it must be supported by good, inquiry-based materials that can be difficult to produce. Here, Professor Schumacher had some good advice: don't be afraid to "steal" from the best. There are a lot of materials that have already been generated. Use them!
- Demonstrating the ways active learning can be approached, Dr. Schumacher showed a variety of classroom-based video clips, encouraging attendees to watch the behaviors of either students or instructors. Then, using good active learning practices, participants shared their perceptions.
- Professor Schumacher urged participants to visit "Discovering the Art of Mathematics" at www.artofmathematics.org/. The project, which provides a wealth of resources to support college faculty in teaching mathematics for liberal arts, offers valuable insights into inquiry-based learning.

Three Active Learning Lessons via Mock Classroom

- Thursday afternoon and most of Friday morning were spent in three active learning mock classrooms, each focused on one of QR's essential outcomes (or competencies).
  - ► ***Numeracy.*** This competency involves developing and using the concepts of numeracy to investigate and explain quantitative relationships and solve complex problems in a variety of real-world contexts.

    In this mock classroom, which was facilitated by Sinclair Community College's Mr. Jim Willis, participants worked in groups to explore a series of cost of living issues, first by creating a simple price index based on gasoline prices, and then using the Consumer Price Index to predict, compare, and contrast transportation costs over an 85-year period. The participants finished by looking at a situation that was similar, but that could be analyzed in a variety of ways.
  - ► ***Mathematical Modeling.*** This competency involves making decisions by analyzing mathematical models, including situations in which the student must recognize and/or make assumptions.

    In this mock classroom, which was facilitated by the University of Cincinnati's Dr. Ricardo Moena, participants were given real-life problems and were told to work out their own solutions without giving them the functions to be used. Participants then explained the underlying assumptions and functions that they used.
  - ► ***Probability and Statistics.*** This competency involves using the language and structure of statistics and probability to investigate, represent, make decisions and draw conclusions from real-world contexts.

    In this mock classroom, which was facilitated by Owens Community College's Ms. Michelle Younker, participants worked in small active learning groups to interpret data in

three graphic presentations. Their instructions were to identify the stories being told by each graphic presentation using the concepts of center (i.e., mean, mode, and median), shape, and spread.

Delivering QR Learning Outcomes and Assessment

- On Friday, after the third set of mock classroom experiences, Cuyahoga Community College's Mr. Aaron Altose led a discussion of the delivery of QR learning outcomes in the classroom. Mr. Altose introduced attendees to the "Problem Cycle: Delivery of Quantitative Reasoning Learning Outcomes in the Classroom." This cycle allows for ongoing learning opportunities, connections in a social/cultural setting, explicit mathematical connections and struggling with important concepts to be introduced at different points in the cycle. In order to construct a Problem Cycle, faculty should consider the following during each stage:
  - Stage 1. Introduction to a Problem: What pre-requisite mathematics skills and contextual information do students need? How can this context be made relevant for students?
  - Stage 2. Student Problem-Solving: Where will students struggle in this lesson? What are your predictions for how students will answer the questions?
  - Stage 3. Whole-Class Discussion about Ways to Solve the Problem: What will you look for in students' group work to structure the whole-class discussion? How can you create connections with other mathematical concepts?
  - Stage 4. Conclusion Facilitated by the Teacher: What are the key mathematical ideas that students must understand? What concepts are still being developed?
- These stages can happen multiple times during a lesson. Mr. Altose then gave participants the opportunity to create their own problem cycles. Throughout a problem cycle and during class, students are expected to communicate, collaborate and be persistent despite struggling. The outcomes for the QR course are to:
  - Engage students in a meaningful intellectual experience.
  - Increase students' quantitative and logical reasoning abilities.
  - Improve students' ability to communicate quantitative ideas.
  - Encourage students to take other courses in the mathematical sciences.
  - Strengthen mathematical abilities that students will need in other disciplines.
- This discussion was followed by a session on assessment challenges, led by Dr. Andrew Tonge from Kent State University. Among the issues addressed in this session were:
  - Why teach QR? It allows students to connect mathematics to their own life experiences; it gives students skills that are increasingly required in the workplace, making them more productive and successful in their careers and life; it halts the cycle of mathematics fear; and it improves students' ability to think critically.
  - How is QR different from the other OTM courses? It is less procedural; there isn't "one right answer; it is anchored in context; and the objects of study are data.
  - What makes QR "college level?" It is the depth of material studied, which deepens, broadens, and/or extends what students learn in K-12.
  - What about assessing QR performance? It needs to be realistic. Working in

context is difficult. Ambiguous contexts are even harder.

- ► What should we expect from students? What we should be looking for is the cultivation of a robust habit of mind, productive persistence and an ability to communicate coherently.
- ► Are there unique assessment challenges? Yes. It is difficult to ensure consistent grading when working with ambiguous/ open-ended questions.
- ► Dr. Tonge encouraged participants to use Quantitative Literacy Value proficiency levels as an assessment tool. In addition, he suggested that instructors think in terms of moving students from: "No, I can't" to "Yes, I can," then to "Yes, I do."
- ► Finally, Dr. Tonge recommended using assessments that value collaborative work – and that reward achievement, rather than those that punish for deficiencies.

The Final Sessions

- As the workshop concluded, Dr. Carol Schumacher moderated a Rapid-Fire Panel that allowed participants to ask questions about what they had learned and the challenges they would face back on campus as they develop or refine their own QR courses – and their own active learning approaches.
- Ms. Michelle Younker closed by tying things together and reflecting on the two-day learning experience. Her reflections and comments about next steps included the following:
  - ► Visit the OMI web site to see materials used during the workshop and other helpful resources.
  - ► Be intentional when developing lessons and have goals, but be prepared to have other information ready to prompt students if they struggle too much with an ambiguous question.
  - ► Address management needs. Be up front with students about the course expectations, such as participation and being engaged during class. Make sure that students understand the instructor's commitment to active learning.