

Revising the Mathematics Education Curriculum at Xavier University

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Introduction

During the 2004-2005 year, the authors met regularly (and sometimes with our colleague Joseph F. Wagner, SJ) to consider the status of Xavier University's mathematics education curriculum, which at the time was a course package consisting of **MATH 110/111/112**, designed to prepare pre-service teachers of primary school level mathematics with a rich content knowledge of school mathematics. We had begun our work during the summer of 2004, educating ourselves about current best practices in preparing mathematics teachers for grade levels K-9. Sheila Doran attended a week-long summer institute, entitled *Developing Teachers' Mathematics Knowledge for Teaching*, at the Center for Proficiency in Teaching Mathematics in Ypsilanti, MI, run by Deborah Ball and Teresa McMahon of the University of Michigan and Paola Sztajn at the University of Georgia. Meanwhile, Danny Otero attended the first of two week-long workshops in the PMET (Preparing Mathematicians to Educate Teachers) program run at Bowling Green State University; he participated in the second part of the workshop in July 2005. After comparing notes in the fall of 2004 about what we had learned, we met with faculty members in the Xavier University Department of Education whose responsibilities are to teach the methods courses in mathematics education and advise the pre-service education students. Meetings with them helped to identify whether there were other issues that would need to be addressed as a redesign of this curriculum were to take place.

The authors were also lucky enough to secure a small grant to support this effort through the Ohio Higher Education Network for the Improvement of Science and Mathematics Education (OHEN), under whose aegis we were able to make day-long visits in February/March 2005 to Wright State University and to Youngstown State University to consult with some of the faculty at these institutions about courses they offer to pre-service middle school mathematics teachers. (Fr. Wagner joined us on our trip to Wright State.) These visits were engaging and profitable experiences for us as we got to observe first-hand how students in these programs work towards "profound understanding of fundamental mathematics." In addition, we attended a series of three afternoon workshops sponsored by OHEN on a variety of issues related to teaching courses for middle school mathematics (on how students learn; on a variety of instructional strategies; and to learn information about other science and math education initiatives under way throughout Ohio).

The Old Curriculum

Before we describe our redesigned mathematics education curriculum, we should first describe the structure of the curriculum it was meant to replace. The Early Childhood (EC)* mathematics curriculum at Xavier consisted of a two-course sequence (**MATH 110 Principles of Contemporary Mathematics**; **MATH 111 Principles of Geometry**) focusing on the principles of school mathematics. MATH 110 treated the foundational mathematics behind arithmetic (concepts of number and arithmetical operations) and basic probability and statistics; MATH 111 was a comprehensive study of plane and solid geometry and measurement. However, *these two courses were not required for EC students*, only strongly suggested; this policy dated back to the early 1990s when the Education Department relaxed the requirement that these courses had to be the ones chosen by education students to fulfill their mathematics course requirements at Xavier. Indeed, EC students could choose to avoid these courses entirely and opt for other kinds of mathematics courses to fulfill core requirements in mathematics.

Middle Childhood (MC)** mathematics students were required to take a total of seven courses (21 credit hours); these were carefully specified. They included MATH 111, **MATH 112 Survey of Problem Solving**—which gave attention to problem solving techniques, logic, set theory, number theory, patterns, functions, and matrices—and five other courses. They were: **MATH 113 Mathematics of Finance** (which develops the mathematics of financial investments like certificates of deposit, annuities, and bonds, but which is a course not easily accessible to many students as it was offered only in the XU Weekend Degree program), **MATH 115 Topics in Applied Mathematics** (a standard non-major-level course including topics in graph theory, voting theory, and patterns of growth), **MATH 116 Elementary Statistics**, **MATH 120 Elementary Functions** (the nature of functions and how they are used to model the real world), **MATH 150 Elements of Calculus I** (one-semester calculus with polynomial, exponential, and logistic functions, emphasizing business and health science applications).

It is worth noting that our MC curriculum was put together in 1998 in response to the announcement by the state of Ohio that a new licensure structure for primary education would now require a third category for middle school teachers mandating special course requirements for licensure (to complement categories for licensure for the earliest grades and for secondary level). The seven-course curriculum was formulated from previously existing introductory mathematics courses that, with the exception of the two courses MATH 111/112 (and possibly also MATH 116), focused little on the mathematical

* The term Early Childhood is used here to describe the programs of Early Childhood Education (PreK-3 licensure), Montessori Education (PreK-3 licensure), Special Education. (Students working toward PreK-3 licensure choose one of the first three programs listed here.)

** The term Middle Childhood is used here to describe programs for students in Middle Childhood Education (Grades 4-9 licensure) *with* mathematics concentration. These students must select two of four possible concentrations: social studies, mathematics, science, or reading/language arts.

preparation of middle school teachers. Even MATH 112, the course that was created in 1998 to address the specific needs of these students, was designed by assembling a collection of topics in a state standards document that were absent from the topics covered by the other courses in the curriculum. In addition, no provision was made for challenging students who came into the program with strong mathematical backgrounds. For instance, in numerous cases in recent years, evidenced by enrollment statistics, students who entered the MC mathematics program with AP Calculus credit were allowed to take MATH 120, essentially a pre-calculus course, for credit.

The New Curriculum

We reorganized the old three-course sequence MATH 110/111/112 into two independent integrated sequences of courses devoted to fostering deep understanding of early-grades and middle-grades mathematics content. The names and numbers for these courses are as follows:

MATH 201 Foundations of Arithmetic for Early Childhood Teachers
MATH 202 Geometry and Measurement for Early Childhood Teachers

MATH 211 Foundations of Arithmetic for Middle Childhood Teachers
MATH 212 Geometry and Measurement for Middle Childhood Teachers
MATH 213 Algebra Concepts for Middle Childhood Teachers
MATH 214 Mathematical Problem Solving for Middle Childhood Teachers

The courses MATH 201/202 and MATH 211/212 replaced the old MATH 110/111. MATH 201/202 treats concepts found in mathematics in early grades curricula. Arithmetic, its theory and practice, place value, fractions, decimals and integers, the importance of patterns and their recognition, an introduction to the ideas of probability and statistics, and proper use of calculators, describe the topics of the first course; basic geometric shapes in one, two and three dimensions, scientific measurement and dimensional analysis, congruence, similarity, a treatment of compass and straightedge constructions, transformational geometry, and coordinate geometry are dealt with in the second of these.

In a significant break with current practice, however, we made the two courses MATH 201/202 *required* for (at least most) students in EC programs. We feel that all students who complete programs in EC education and hope to teach young children will benefit from experiences that ask them to think hard about the mathematical content of the curriculum of the early grades, and in any case, will serve them better than many of the other mathematics courses otherwise available to them.

MATH 211/212 explore mainly the same topics as in MATH 201/202, but include additional topics from the mathematics of the middle grades (basic set theory, the algebraic properties of arithmetic, prime factorization and introductory number theory, percents, scientific notation, and irrational numbers in the first course; and conjecture and

proof in geometry, perspective drawing, and an introduction to trigonometry in the second) and exclude treatment of topics in probability and statistics.

MATH 213 and MATH 214 form a second-year curriculum for building deep understanding of the mathematical concepts of school mathematics for MC students. MATH 213 explores algebraic notation and problem solving, mathematical functions as tools for representation of patterns, a study of sequences and geometric series, linear, quadratic, and exponential equations, and appropriate use of technology in the study of algebra. The final course, MATH 214, is envisioned as a problem solving seminar in which students are asked to make broad connections amongst the concepts laid out in school mathematics. In addition, some other topics are studied: systematic Boolean logic, basic combinatorics, and basic probability theory.

Conscious attention to the power and importance of problem solving techniques in school mathematics permeate all six of these courses. Attempts are made to include significant consideration to elements of the history of mathematics throughout. In addition, the communication of mathematical ideas is meant to be an important component of all student work in these courses.

The MC curriculum of seven semester courses in mathematics now includes the new sequence MATH 211/212/213/214 and, typically, these three additional courses: MATH 120 (Elementary Functions), MATH 150 (Elements of Calculus), and either **MATH 116 Elementary Statistics** or **MATH 156 General Statistics**.^{***}

The six new courses described here, except for MATH 214, will carry no prerequisites other than sophomore standing. (MATH 214 will have MATH 211/212/213 as prerequisites.) But this in itself is a change from traditional practice at Xavier, as the old curriculum allowed (and often encouraged) students to finish their mathematics course work in their first year. It is our conviction that EC and MC students alike should complete an introductory education course before starting any of these six mathematics courses so that they will have been exposed to thinking about what it means to guide the education of children, and so that they can better appreciate the need for thorough content background. We hope that EC students will delay their mathematical coursework until the sophomore year, and that MC students will take the three 100-level math courses MATH 120, MATH 150, and MATH 116/156 during their freshman year, *before* they begin the MATH 210 series. We have chosen to number these courses at the 200 level to impress upon the university community that the courses proposed here are *professional*

^{***} Entering students at Xavier are placed through testing into essentially four tracks in mathematics: Remedial (requiring students to complete **MATH 105 Intermediate Algebra** before they can enroll in any other mathematics courses), Pre-calculus (the level of the current MATH 110/111/112 and MATH 120 courses), Calculus (MATH 150), and Advanced (students demonstrate sufficient proficiency for the science/mathematics major level **MATH 170 Calculus I** or **MATH 171 Calculus II**). MC students who place at the Calculus or Advanced level are now advised to start their mathematics coursework at the recommended level and will be discouraged from enrolling in courses at a lower level.

level mathematics courses, not an attempt to justify college credit for grade school level content! (This is a sentiment regarding the current MATH 110/111/112 that has held uncomfortably wide support, and it is reinforced by the fact that these course numbers were the lowest in the mathematics curriculum, save the remedial course MATH 105.) We have also crafted directives for advisors of students in all of these programs that assist them in guiding their students into appropriate mathematical coursework.

The Process

This curriculum redesign was completed in June 2005. Syllabi were created for all of these courses and the package was offered for consideration and approval by the Department of Mathematics & Computer Science. It then received the endorsement of the Education Department and traveled through the College and University curriculum committees for official university ratification by then end of the 2005-2006 academic year. Meanwhile, we continued to run MATH 110/111/112 during the Fall 2005/Spring 2006 semesters, all the while testing a number of the topical revisions from the new curriculum. We have launched the entire new curriculum during the 2006-2007 academic year. It is anticipated that one section each of MATH 201, MATH 211, and MATH 213 will run each fall, and one section each of MATH 202, MATH 212, and MATH 214 will run in spring semesters. (Note that in 2006-2007, the second-year sequence MATH 213/214 will not run; it will launch in the following academic year.)