College Algebra—Modeling the City

Engaging Mathematics Teaching Manual

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Contents

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This teaching manual was created for Engaging Mathematics with support from the National Science Foundation.

An initiative of the National Center for Science and Civic Engagement, Engaging Mathematics applies the well-established SENCER method to college level mathematics courses, with the goal of using civic issues to make math more relevant to students.

Engaging Mathematics will: (1) develop and deliver enhanced and new mathematics courses and course modules that engage students through meaningful civic applications, (2) draw upon state-of-the-art curriculum in mathematics, already developed through federal and other support programs, to complement and broaden the impact of the SENCER approach to course design, (3) create a wider community of mathematics scholars within SENCER capable of implementing and sustaining curricular reforms, (4) broaden project impacts beyond SENCER by offering national dissemination through workshops, online webinars, publications, presentations at local, regional, and national venues, and catalytic site visits, and (5) develop assessment tools to monitor students' perceptions of the usefulness of mathematics, interest and confidence in doing mathematics, growth in knowledge content, and ability to apply mathematics to better understand complex civic issues.

Updates and resources developed throughout the initiative will be available online at `http://www.engagingmathematics.net`. Follow the initiative on Twitter: @MathEngaging.

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0.1 Introduction—About Roosevelt University and the Course

Attached—syllabus, class calendar, sample Daily Quizzes, sample Guided Lesson Notes, sample Chicago based problems, the Big Problems, and Day One PowerPoint.

Roosevelt University is an independent, nonprofit, metropolitan university with its main campus in downtown Chicago. MATH 121 *College Algebra* is a 3 credit hour semester-long math course that meets twice a week for 75 minutes per class. The class is required for math, science, computer science, and business majors, but potentially taken by any undergraduate student. For some students, *College Algebra* is their first college math course, but many incoming students must take a non-credit developmental math course before entering *College Algebra*. Math and science majors are also required to take the next course in the sequence, *Pre-Calculus*. The *College Algebra* course had been taught in the traditional lecture format using the textbook *Algebra and Trigonometry: An Early Functions Approach*, Second Edition, by Blitzer, (Pearson Prentice Hall) and its companion MyMathLab site for online homework. The course content is fairly typical of a college algebra course—graphs and equations for polynomial, exponential, and logarithmic functions.

0.2 Problem Statement

The challenges that Roosevelt's *College Algebra* course had been facing fall into three categories:

- **Attitude**: Students who lack an interest in the subject or the motivation to learn: "I've never been good at math;" "When am I ever going to use this?"
- **Behavior**: Students who do not regularly attend class or are unprepared for class; a lack of engagement during class; an unwillingness to ask for help from faculty, tutors, or peers
- **Performance**: Students who have forgotten (or never had) pre-requisite skills; low pass rates for the class (about 65%); students not preforming well in *Pre-Calculus*; underdeveloped study skills; students overwhelmed by amount of content covered in each class

0.3 Goals of Revision

As part of the NSF-funded SENCER project *Engaging Mathematics*, the revision of Roosevelt University's *College Algebra* course aims to address and overcome these challenges of attitude, behavior, and performance. Specifically, the new version of the course needs to be more engaging and interesting. The course needs to give students the chance to show what they do know and practice what they don't. The course needs to provide a safe and supportive environment for learning with feedback and positive reinforcement. The course needs to offer students the opportunity to communicate with others and to seek assistance in and out of the classroom. Class time needs to be productive and worthwhile to students. The course needs to teach and facilitate successful academic behaviors that will be beneficial not only in this course but also in other courses. Ultimately, the course needs to increase and improve learning in order to improve pass rates in this and subsequent courses.

The changes made to the course include: Chicago-based problems and data modeling, a new "flipped" format, and a more active learning classroom environment. The same textbook is being used, but the assignments and use of class time have changed.

0.4 Chicago Problems

Chicago Problems: SENCER's mission states "SENCER courses and programs strengthen student learning and interest in the sciences, technology, engineering, and mathematics by connecting course topics to issues of critical local, national, and global importance." Roosevelt's University Learning Goals are 1) effective communication, 2) knowledge of disciplined-focused content, and 3) awareness of social justice and engagement in civic life. With these missions as a guide, the revised *College Algebra* course has the theme of *Chicago: Modeling the City*. (The majority of Roosevelt University students are from Chicago, or at least from Illinois.) Throughout the course, problems use Chicago-based situations instead of generic ones. This has been done on a small scale as well as a larger scale (see Guided Lesson Notes and Big Problems). When students are interested in the content, they are more engaged, have a better attitude, and ultimately perform better.

> As one student said, *"I saw connections between math and my everyday life."* [All quotes are direct student statements from the SALG survey.]

Big Problems: End of chapter Big Problems focus on one topic but ask a number of questions. Some are data analysis or modeling and others delve more deeply into a topic that has already been introduced. Most of the Big Problems also have a Chicago connection. Topics include Chicago population, Chicago homicide rates, temperature conversions, Blood Alcohol Concentration, and the Chicago Skyway tolls. (See Big Problems.)

These end-of-chapter problems are a good way to review concepts and skills before moving on to the next chapter. They ask student to synthesize material from more than one section and put into practice a variety of skills to approach and solve problems.

> *"The big problems were very helpful in tying together ideas and thinking about math as a tool to solve real world problems instead of numbers on a page."*

> *"Growing up many students always ask how math will be able to transition into the real world. Part of the example problems that we had to do were applicable to real life situations. For example, the BAC, BMI, compound interest."*

Extra Credit: Throughout the semester, there are various extra credit questions in the Guided Lesson Notes and the Big Problems. These ask students to research and write about a topic examined during class. For example, at the end of Big Problem focused on temperature scales and conversions, students can research and report on the 1995 Chicago heat wave that resulted in 700 deaths. They are asked to comment specifically on the inequity in these deaths in geographical, racial, and socioeconomic terms. The Big Problems and the Extra Credit questions show students the connection between math and other subjects as well as the connection between the classroom and the rest of the world.

0.5 Course Components

New Flipped Course Format and Components

The course is now taught in a "flipped" format, meaning that students learn basic algebra skills outside of class in order to spend class time applying those skills to larger, more complex problems. In this new revised format, each textbook section includes three assignments, all of which are accessed by students through the class MyMathLab course environment. The first assignment, the **Learning Guide**, has links to the e-book, a short instructional lecture video, and PowerPoint notes. The second assignment, the **Skills Homework**, are math questions that require basic skills. The third assignment, **Problem Set**, includes more challenging problems and application questions. The Learning Guide and Skills Homework are pre-class work and the Problem Sets is post-class work. Students are given a course calendar with specific due dates and times.

Each class session begins with a short **Quiz**. The 10-minute, two question quiz has one question from that day's pre-class Skills Homework and one question from a previous lesson. For each section there are **Guided Lesson Notes** with specific questions and problems to be covered during class. After each chapter, a class is spent on a **Big Problem** that applies many concepts from that chapter to a larger "real world" problem. There are two **Tests** during the semester and one comprehensive **Final Exam**. For these tests, there is a "calculator allowed" section and a "no calculator" section. Before the Final Exam, each student creates a **Student Generated Study Guide** for one section. These study guides are shared with the entire class.

0.6 Pedagogical Foundations

Pedagogical Foundation for Course Components:

Learning Guide and Skills Homework then Problem Set: These assignments require students to engage with the material before coming to class as well as after. The Learning Guide encourages students to read the text and to take notes. Note-taking is one of the successful academic behaviors that many students don't do or struggle with. Improving this skill will help not only in this course but also in all college courses. Often in a non-flipped class, so much time is spent on introducing concepts and teaching basic skills that little (or no) time is spent showing students how to approach and work through more complex problems. When students then encounter these types of problems on homework or tests, they often struggle with synthesizing earlier concepts to solve them. In a flipped class, basic skills are covered before class, so much more class time is spent building more advanced skills. These more advanced skills are used in the Problem Set assignment done after class.

There is time to teach strategies for how to approach complex problems, how to work through applied word problems, and how to apply math concepts to more realistic problems. Instead of seeing math as a series of steps used to solve abstract problems, students in flipped classrooms have the opportunity to use mathematics in a real and relevant way and to improve problem solving and critical thinking skills.

> *"I liked how we first encountered the new sections on our own and then we would go into class and expand on those concepts instead of the opposite."*

> *"The problem set homework really helped me put together all the main ideas."*

> *"I enjoyed the online learning and then doing the big problems in class. It helped me to take my own notes and participate more fully in my own education which helped to remember key ideas."*

> *"I feel much relaxed about being able to solve complex math problems."*

Quizzes: Frequent, short, low-stakes assessments provide necessary feedback to students. Because of the use of the Help Tools in MyMathLab and the ability to do Homework problems more than once, many students have high grades on the Skills Homework. However, those high grades do not always reflect deep learning. Daily in-class quizzes give students feedback on whether they have actually learned these basic skills. The quizzes can pinpoint topics to review within the chapter before the larger assessment of midterm tests.

> *"We took a quiz every class so it's good because you need to work on the problem for that class to understand the quiz, which helped me do well in class."*

Guided Lesson Notes: Class time is used to complete the Guided Lesson Notes, which are projected on the screen during class. These notes include **Writing in Mathematics** questions, a review of basic skills, and more advanced problems, many of which are Chicago based. Class ends with a student reflection section.

During class, some time is spent on lecture and demonstration, and some time is spent on individual work or small group work to complete the Guided Lesson Notes. During lecture and demonstration, there is still an active learning environment with questions being asked of the students. While students are working alone or in groups, the instructor is circulating the room. Instead of talking *at* students, instructors can talk *with* students by asking and answering questions, checking answers, and correcting mistakes. Often students are asked to share or show their process and answers with the class.

Responding to questions from the instructor during lecture requires attention and engagement; students cannot just sit and listen passively. Small group work requires students to connect and communicate with each other. Students can see different ways to work a problem, can see and correct common mistakes, and can hear or provide an explanation different from that of the instructor. Making connections with other students can also improve attitudes and change behavior. Students find that sometimes they ask for help and sometimes they give the help. When students know each other in class, they feel more accountability to come to class and form study groups outside of class. In addition to doing Active Learning, time is spent discussing it (see Day One PowerPoint). Students are often reminded why class is conducted in the way it is. The potential benefits are stated explicitly.

> *"Partner work and discussing answers and why we got the answers we did were a daily routine in class which helped greatly."*

> *"Seeing how others work on problems is always beneficial because it gives you a different way of thinking and problem solving."*

At the end of each class, students are asked to reflect and rate their ability to do the skills listed in that section's objectives. For any skill for which they rate themselves low, they are directed to the Study Plan on MyMathLab for more practice. This self-evaluation is important because it provides the opportunity to reflect on their level of understanding. This metacognition can help them monitor and be more responsible for their learning process and supports behavioral changes to achieve or deepen that learning.

> *"I gained group work skills, not being afraid to seek others. I can also feel how to solve college algebra problems which may seem hard."*

Writing in Mathematics: The Guided Lesson Notes begin with questions that ask students to write definitions, explain concepts, or describe algorithms. (See examples of Guided Lesson Notes.) Students initially work alone on these questions, but then collaborate with nearby peers to compare answers. This is another source of feedback for the students on what they learned from the pre-class assignments. If they read the text, watched the instructional video, took thorough notes, and did well on the Skills Homework, they should be able to answer these questions. Discussing and explaining concepts and skills to other students are mutually beneficial for both the explainer and the explainee.

> *"I have gained being able to speak to others about math by having to compare and contrast our answers."*

0.7 Future Plans

Future: We have surveyed the students to ask what type of issues related to Chicago they would be interested in learning about in order to inform revision or addition of new questions and problems. We may make the extra credit questions required into a larger project. As more instructors teach the course, we will have more input on the structure and flow and suggestions for changes. We will continue to assess student learning in a variety of ways.

0.8 Advice

Information/Advice for other schools: While the flipped format has been gaining popularity nationally, it is important to plan your flip carefully and thoughtfully. To create our course without changing textbooks, we had to create all new assignments and fully utilize the text's MyMathLab site. When developing assignments, carefully consider what you are asking students to do and learn before class. It should be reasonably manageable in quantity and perceived difficulty. The problems for the Skills Homework had to be chosen carefully to cover skills that students can reasonably pick up on their own (with the help of the Learning Guide). Many students have a hard time reading textbooks, so our Learning Guides not only have text but also videos, PowerPoint notes, and animations. This combination gives options for a variety of learning styles. I would recommend, at least at first, using course materials that come with online and/or video resources instead of creating your own from scratch. There are many resources available—MyMathLab from Pearson, WebAssign, Khan Academy, etc. Also, it is very important to the course's success that the flipped format and the rationale for the flipped format are explained clearly and carefully. Students need to understand that they are not being asked to teach themselves everything and that this is not the same as an online class. Class time should not merely be a review of the same concepts and skills done before class, but should reinforce those concepts and skills and build to more complex concepts and skills. Otherwise, students do not see class time as valuable.

Obviously, not all schools would be interested in focusing on Chicago, but you can use our materials as suggestions or examples for what you can do with your own course to make it more relevant to your students. Find out what they are interested in. Instead of focusing on a city, you could look at some of the same topics on a national scale.

For the modeling questions (population and homicide rates), we gave students the data and the graph and eventually the model equation. Depending on your time and access to technology, these types of problems could be expanded to teach graphing and model fitting and/or to show the uses of spreadsheets or statistical software. We are planning to focus more on modeling and data fitting in the future.