Designing an Online Math Literacy Course Using Free Materials

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The Problem

At the request of our military program, we were tasked to create an online version of our non-STEM algebra course (what many call Math Literacy for the College Student). The original course was designed to use active learning activities as the primary instructional mode, which posed a big challenge for transitioning the course to online.

Background

Pierce College's learning materials for this course were based on the original openly licensed Quantway materials, and have been substantially revised by the department over the last two years. The learning materials take the form of a daily lesson, and most of the class time is spent with student students working through the lesson in groups. We also have online "prep" assignments which provide unlimited randomized practice with skills questions, and online "homework" assignments which are mostly non-randomized contextual problems.

The Challenges

Our biggest concerns when putting the materials online were:

- Preserving the active-learning, problem solving, and productive persistence focuses of this course in an online environment.
    - Avoiding over-scaffolding the questions
    - Encouraging students to try problems on their own before seeking help
- Providing sufficient hints and guidance for students during the lessons so students will be able to learn what they need to learn from the lessons.
- Provide hints and guidance in a timely manner, so students aren't blocked in their progress through the course.
    - Since our course had to be asynchronous, this eliminated discussion forums or instructor messages/email as the primary mechanism for help and guidance.

Our Approach

We used WAMAP (aka MyOpenMath) as the platform. It is an open system, which makes it easy to develop original content. It supports algorithmic questions and grading of algebraic, numeric, and graphical answers. Our "prep" and "homework" assignments were already built in this system.

The lessons were rebuilt in the online platform with only minor modifications. To motivate students to work through these and try the problems on their own:

- The lessons were worth 10% of the course grade.
- Wrong answers incur a 10% penalty, encouraging students to try the problem on their own.
- If students miss a problem, they can get ~70% of the credit just for typing in the correct answer shown to them. This rewards engaging with the material and actually reading the answer.

We differentiated problems into three levels, with differing supports provided:

1. Basic questions with single-step solutions. For these, we give the students 3 tries at the problem, then display a detailed answer walking through how to do the problem. If the student is unable to solve the problem on their own, this turns the problem into the equivalent of a worked example.
2. Questions with common student hang-ups. For these, we give students hints after 2 tries at the problem. In some cases these hints are progressive, revealing more detail after each attempt.
3. Complex questions with multiple steps. To encourage students to reason through the problem solving process, these are initially presented without scaffolding and with a single answer blank. If the student misses the question twice, the question is presented with scaffolding to guide the student through the process.

With all of these, if students miss the problem they are shown a detailed solution and can earn partial credit for entering the answer. After the due date, students can always go back to the assignment and will have access to the detailed solutions we provide.

Structure

The course is broken up into weeks. In each week a student works through 3-4 sections, each of which consists of

- A "prep" assignment that reviews pre-algebra and algebra skills needed for the lesson
- The lesson itself
- A homework assignment that practices and applies the skills learned in the lesson

At the end of each week there is

- A timed online quiz consisting of problems similar to the homework
- A "Show Your Work" assignment where students have to submit a picture of their worked solution to a particular problem
- A "Learning Forum" assignment where they post in forum about their learning experience that week: something they learned, something they struggled with, etc.

There is a proctored midterm and a proctored final, which is the same common final given to on-campus sections.

Grading:

- Engagement
    - Lessons: 10%
    - SYW and Learning Forum: 5%
- Homework
    - Preps: 5%
    - Homework: 10%
- Quizzes: 20%
- Midterm: 20%
- Comprehensive Final: 30%

Online Course Results

Retention

- Spring: 26 students on the 5th day, 23 persisted to the final (88%)
- Summer: 22 students on the 5th day, 17 persisted to the final (77%)

Success (2.0 or higher, out of all students on the roster, including those who withdrew after 10th day)

- Spring: 64% Dept avg: 68%
- Summer: 57% Dept avg: 68%

General Course Results (based on on-campus sections)

- Of students who started in Fall 2013 in our old pathway, within 3 quarters
    - 20% had completed college-level math
    - 14% of African American students had
- Of students who started in Fall 2015 in our new pathway, within 3 quarters
    - 32% had completed college-level math
    - 29% of African American students had

Exploring the Course

The materials for the on-campus course and the online course are shared openly on MyOpenMath (outside WA) and WAMAP (inside WA).

- Visit MyOpenMath.com.
- Request an instructor account, create a student account, or just login as "guest" with no password. If requesting an instructor account, you do not need to way for your account to be approved.
- Log in.
- Click Enroll in a New Class
- Enter Course ID: **17090**, Enrollment Key: **AMATYC16**

This will give you student-level access to the course to look at the assignments and lessons.

To explore deeper, request an instructor account. Once approved you can create a new course, copying our materials. There are links in the course to all the Word files if you wanted to make modifications or adaptations.

Questions

For questions about the course, you can contact me at dlippman@pierce.ctc.edu

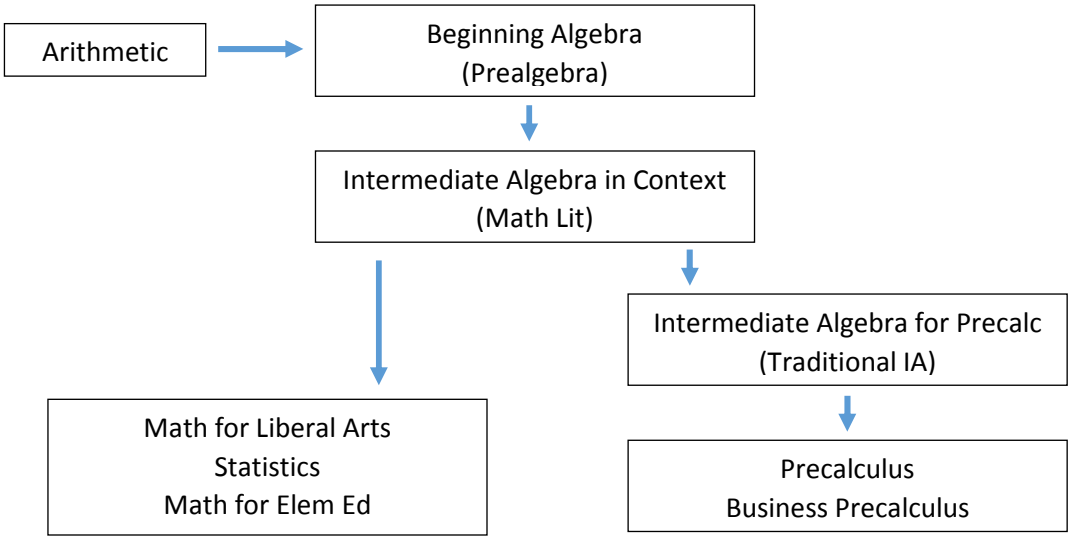
Course Background

As part of our Achieving the Dream initiatives, we were given funding to work on redesigning our developmental curriculum. During a summer workshop, about 20 full-time and part-time faculty gathered to answer the question "what skills do students *need* to be ready for their college-level course." It became apparent that some skills we were teaching in dev-ed were unnecessary, but much more apparent that the skills needed for pre-calculus were very different than the skills for our non-STEM courses like statistics and math for liberal arts. We decided to work on building a non-STEM algebra course. We also made some changes to our prealgebra courses, and revised our traditional intermediate algebra to remove to topics we didn't think they really needed.

A team of faculty worked on defining the course outcomes (SLOs), which were largely based on the Math Literacy for College Students and Quantway outcomes, but also included some algebraic topics we felt were needed. The team reviewed all existing curriculum options, including Almy/Foes Math Lit, Dana Center's NMP, Sobeki/Mercer Math Pathways, and Quantway. None exactly matched the outcomes they defined. The team decided they liked the authenticity of the Quantway applications, so the decision was made to start with the original openly licensed version of Quantway and supplement with the topics needed.

The team developed a one-day training for those wanting to teach the course. Everyone teaching the class met monthly to share strategies, suggestion revisions, and plan assessments. The initial version of the course was taught for year, with minor revisions made each quarter. At the end of the year everyone collaborated on a revision plan, and a group of faculty worked through the summer to make some major revisions to the structure and lessons. At the end of the second year some additional, but more minor, changes were made.

For me, working on the course materials has been a highlight of my career. It is one of the few times I've seen a group of faculty get together to collaborate on designing and improving the course materials for a class. It is exactly what open resource can and should enable.



Intermediate Algebra in Context (aka Math Lit) Course Outcomes (SLOs)

Credits: 7 quarter credits (≈ 5 semester credits)

Course Description:

This course integrates numeracy, proportional reasoning, algebraic skills, and functional reasoning. Students will represent quantitative relationships in multiple ways in order to solve problems from a variety of authentic contexts. Linear and exponential functions, along with logarithms and radicals will be studied and applied. Modeling and interpreting quantitative data is emphasized.

Outcomes:

Numeracy

1. Demonstrate operation sense by communicating in words and symbols the effects of operations on numbers. Apply the correct order of operations in evaluating expressions and formulas.
2. Demonstrate an understanding of the magnitude of real numbers represented in many forms (fractions, decimals, scientific notation, square roots of numbers) by ordering and comparing them in mathematical and real-world contexts.
3. Estimate results in appropriate contexts, using appropriate precision; use estimation to detect errors and evaluate the reasonableness of answers.
4. Use dimensional analysis to convert units, rates, and ratios from any given units to other units. Include conversions among and between U.S. and metric units using a variety of metric prefixes.
5. Demonstrate measurement sense by determining the sizes of objects and angles using measurements and estimation. Determine perimeter, area, surface area, and volume using appropriate units in both the U.S. and metric systems.
6. Demonstrate an understanding of the connection between the distribution of data and various mathematical summaries of data (measures of central tendency and of variation).
7. Read, interpret, and make decisions based upon data from tables and graphical displays such as line graphs, bar graphs, scatterplots, pie charts, and histograms. Given data, choose an appropriate type of graphical display and create it using scales appropriate to the application.

Proportional Reasoning

8. Recognize a proportional relationship from verbal, numeric, and visual representations. Link and create verbal, numeric, visual and symbolic representations of the relationship.
9. Compare proportional relationships represented in different ways, considering units when doing so.
10. Apply quantitative reasoning strategies to solve real-world problems with proportional relationships using whole numbers, fractions, decimals, and percents as appropriate.

Algebraic Skills and Reasoning

11. Distinguish between variables and constants. Represent real-world problem situations using variables and constants. Construct equations to represent relationships between unknown quantities.
12. Simplify algebraic expressions by using the distributive property, combining like terms, and factoring out a greatest common factor.
13. Evaluate formulas with multiple variables in a variety of contexts, including science, statistics, geometry, and financial math. Solve simple formulas for a specified variable.
14. Distinguish between expressions and equations and apply appropriate methods to each.
15. Solve linear equations in one variable, including problems involving the distributive property and fractions.
16. Construct inequalities to represent relationships, solve simple and compound inequalities in one variable, represent solutions using interval notation, and interpret solutions in the context of the situation.
17. Use basic exponent rules to simplify expressions, including those with negative exponents.
18. Solve basic power equations of the form xn = b using radicals.
19. Use the Pythagorean Theorem when appropriate in problem situations.

Functional Reasoning

20. Translate problems from a variety of contexts into mathematical representation and vice versa (linear, exponential, simple quadratics).
21. Describe the behavior of common types of functions using words, algebraic symbols, graphs, and tables. Include descriptions of the dependent and independent variables.
22. Identify when a linear model is reasonable for a given situation and, when appropriate, formulate a linear model. In the context of the situation interpret the slope and intercepts and determine the reasonable domain and range.
23. Determine the exponential function for a situation when given an initial value and either the growth/decay rate or a second function value. Interpret the initial value and growth rate of an exponential function. Include compound interest as one application.
24. Translate exponential statements to equivalent logarithmic statements, interpret logarithmic scales, and use logarithms to solve basic exponential equations.
25. Use functional models to make predictions and solve problems.

General Skills

26. Extract relevant information from complex scenarios. Obtain any necessary additional information from outside sources. Synthesize the information in order to solve problems and make decisions.
27. Identify which mathematical skills to use and then apply them in diverse scenarios and contexts.
28. Clearly communicate solution processes. Write solutions in the context of the problem in complete sentences, including units. Use mathematical notation and vocabulary correctly.
29. Use technology appropriately including calculators and computers.

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Examples comparing on-campus active learning activities with online replacements

From the On-Campus Lesson Packet 2.6

Mountain States

	2000 Population	2010 Population	Absolute Change	Percentage Change
Arizona	5,130,632	6,392,017		
Colorado	4,301,261	5,029,196		
Idaho	1,293,953	1,567,582		
Montana	902,195	989,415		
Nevada	1,998,257	2,700,551		
New Mexico	1,819,046	2,059,179		
Utah	2,233,169	2,763,885		
Wyoming	493,782	563,626		
Mountain Region				

(1) For your group of states, calculate the absolute change in the population of each state.

(2) For your group of states, calculate the relative change in the population of each state. Express your answer as a percentage.

(3) List in order the three states that had the largest absolute changes in population.

(4) List in order the three states that had the largest relative increase in population.

(5) Explain why the lists in Question 3 and Questions 4 are not the same.

(6) For the region you are given, calculate the absolute change in total population from 2000 to 2010. Calculate the relative change in total population between 2000 and 2010.

While most states that lost representatives did so because their population became smaller relative to other states, Michigan's population actually fell between 2000 and 2010.

(7) Michigan's population changed to 9,833,640 from 9,938,444. What was the absolute decrease in Michigan's population? What was the relative change in Michigan's population? Round your answer to the nearest hundredth of a percent.

From the On-Campus Lesson Packet 2.4

Activity: Classroom population density

(3) Consider the classroom and the people in it now. Calculate the population density of the room. Some measuring instruments such as tape measures or meter sticks will be needed.

(4) Next the people in the room will move around.

(a) Consider the room to be a "county" containing a city, a suburb, and rural area.

- Designate one corner of the room as "the city". Some students should crowd together there.
- Designate another corner of the room as "the suburb". Some students should move there, but it won't be as crowded as the city.
- Everyone else is scattered about the rest of the room in the "rural area".

Each group should determine the population density of their area. You'll need to know the boundary of the city and suburb (which can be rectangular shaped) and use measuring instruments as needed.

Each group should record their answers so that everyone can see the results. Record results here:

(b) Compare the population density of the city and the suburb. The city's population density is how many times that of the suburb?

(c) Did the population density of the "county" (the classroom as a whole) change when people moved to the city and suburb?

(5) Imagine a very crowded large city, with each person standing on his or her own 2-foot-by-2-foot square, where the squares are adjacent. Calculate the population density per square mile. Be ready to explain your reasoning after working with your group members. (1 mile = 5,280 feet)

(6) Imagine an average city like Lakewood or Puyallup, where each person could stand on his or her own 100-foot-by-100-foot square. Calculate the population density per square mile.

From the Online Version Lesson 2.6

1. In 2000, the population of Nevada was 1,998,257. In 2010, the population had grown to 2,700,551. Compute the absolute and relative change in the population from 2000 to 2010.

   The absolute change was: ____ people

   The relative change was: ____ % (rounded to 2 decimal places)

2. Compute the absolute and relative change for the states below.

State	2000 Population	2010 Population	Absolute Change	Relative Change (to 2 decimal places)
New York	18,976,457	19,378,102		%
Texas	20,851,820	25,145,561		%
Florida	15,982,378	18,801,310		%
Michigan	9,938,444	9,883,640		%

3. Of the five states you've now calculated the absolute and relative change for,

   a) which has had the largest absolute change in population?

      i) Nevada ii) New York iii) Texas iv) Florida v) Michigan

   b) which has had the largest relative change in population?

      i) Nevada ii) New York iii) Texas iv) Florida v) Michigan

4. Why are the answers to the two parts of the last question different? Select all that are true.

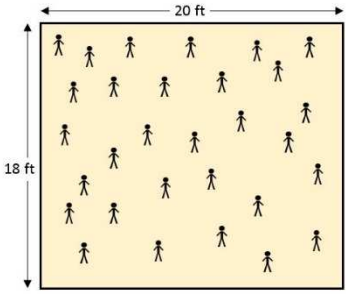
- A large absolute change may not be a large relative change if the starting population was large.
- A large absolute change may not be a large relative change if the starting population was small.
- A large relative change may not be a large absolute change if the starting population was large.
- A large relative change may not be a large absolute change if the starting population was small.

5. Michigan's population changed from 9,938,444 to 9,883,640. Which are correct ways to describe the change? (select all that are correct)

- Michigan's population increased by 54,804 people
- Michigan's population increased by -54,804 people
- Michigan's population decreased by 54,804 people
- Michigan's population decreased by -54,804 people
- Michigan's population changed by 54,804 people
- Michigan's population changed by -54,804 people

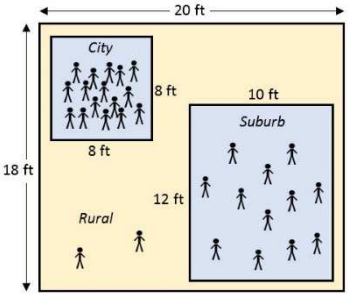
From the Online Version Lesson 2.4

3. In the picture shown, there are 30 students standing in a 18 foot by 20 foot rectangle. Calculate the population density (rounded to 2 decimal places), selecting the appropriate units.



_____ (people, feet, square feet, people per foot, people per square foot, feet per person, square feet per person)

4. In the picture to the right, 16 students have crowded into the 8ft by 8ft region designated the "city", while 12 students are in the 12ft by 10ft region designed the "suburb". Calculate the population density of each region (rounded to 2 decimal places), selecting the appropriate units.



Population density of the "city" region: _____ (people, feet, square feet, people per foot, people per square foot, feet per person, square feet per person)

Population density of the "suburb" region: _____ (people, feet, square feet, people per foot, people per square foot, feet per person, square feet per person)

5. Compare the population density of the city and the suburb regions.

The population density of the city is ____ times the population density of the suburb.

6. Did the population density of the “county” (the classroom as a whole) change when people moved to the city and suburb (as compared to when they were scattered throughout the room)?

- No, the population density of the country didn't change
- Yes, the population density is smaller after the move
- Yes, the population density is larger after the move

7. Imagine a very crowded large city, with each person standing on his or her own 2-foot-by-2-foot square, where the squares are adjacent. Calculate the population density per square mile. (1 mile = 5,280 feet)

Try the problem on your own first. If you are having trouble after 2 tries, we will break it down.

Population density: ____ people per square mile

8. Imagine an average city like Lakewood or Puyallup, where each person could stand on his or her own 100-foot-by-100-foot square. Calculate the population density per square mile, to the nearest whole person.

_____ people per square mile