Below is a description of the course development work that Dr. Robert Tubbs and I completed during spring semester 2016.

**Introduction**

The new course, Mathematics 1212: Data and Models, was designed to be an alternative to, and eventually a replacement for, College Algebra (MATH 1011), for students intending to enter a major that requires a Statistics course. The impetus for developing such a replacement of College Algebra came from the recommendation of the Colorado Math Pathways Task Force Research that College Algebra should not be the default general mathematics course but that institutions should design introductory courses that better prepare students for their chosen major. This push to replace College Algebra with specific math pathways courses emerged from the data that indicated that the standard College Algebra course is an ineffective course for most of the students who go on to take another math course, especially those who are bound for a STEM major that requires Calculus, as measured by these students’ persistence in math classes.

Students who are not headed for a major that requires Calculus, but whose major requires some mathematical thinking, are likely to find the tools of algebraic manipulation less useful than other quantitative skills such as modeling and quantitative reasoning. It is with these students in mind that MATH 1212 was proposed. Instead of focusing on symbolic and algebraic manipulations, the new course will focus more on real-world modeling problems and quantitative reasoning. This course will be specifically designed for students who plan to take statistics, (particularly MATH 2510, Intro to Statistics) or a discipline-specific statistics course such as PSYC 3101), thus providing a more focused pathway to success in those courses.

MATH 1212 has been approved by the College of Arts and Sciences and has been approved by the Curriculum Committee to count for QRMS Core-credit. It will be offered for the first time in Fall 2016 as a single pilot section in the Sewall Residential Academic Program.

**What did you do in the course transformation?**

*What happened and how was the work structured?*

At the beginning of this project, the scope of the new course was very extensive. We all initially hoped that the new course might be able to include most of the material from the College Algebra course, which math faculty have traditionally viewed as the essential knowledge for any student, plus a great deal of additional material focused on analyzing data, modeling real-world situations using functions, and setting up word problems. We began the course development project by compiling an ambitious list of learning goals for the hypothetical course, including the full list of skills typically covered in College Algebra.
We created a survey containing our proposed learning goals and mathematical skills for the new course, and sent it to the various departments that offer statistics courses and/or require mathematical reasoning but not Calculus. We received responses from most of the departments. We were surprised at how the respondents largely rated algebra skills as "unimportant" or "somewhat important". After reviewing the responses, we revised our course plan and learning goals to place more emphasis on modeling and to further de-emphasize skills of algebraic manipulation. While the algebraic manipulation goals are still listed, they are de-emphasized in the course schedule. (We also realized around this time that our full wish list of learning goals was not practical for a 3-credit course!) It will be interesting to see whether this de-emphasis of algebraic manipulation skills impacts students' success (as measured by DFW rates and grade distribution) in later courses: MATH 2510 (Intro to Statistics) or a discipline-specific statistics course such as PSYC 3101.

After finding a potential textbook, we selected topics that reflect our learning goals. We wrote a sample course schedule with these topics. We also created some sample materials for the course, such as a syllabus, course grading scheme, midterm exam, some in-class worksheet projects, an in-class guided activity, and a sample homework solution rubric.

We worked on our own and collaborated during weekly meetings. We also sought input from Stephanie Chasteen and from David Grant and Faan Tone Liu in the Math department.

**Individuals Involved (List name and role)**

- Erica Shannon, graduate student – led the work
- Robert Tubbs, Professor – faculty advisor
- Stephanie Chasteen, TRESTLE PI – provided advice and met a few times
- David Grant, Mathematics Department Chair – provided feedback
- Faan Tone Liu, Calculus Program Coordinator / Mathematics Instructor – provided feedback
- Kevin Manley, Mathematics Instructor – provided feedback

**Learning Goals Developed (List)**

**Course-level Learning Goals**

1. **Thoughtfully read and think about** a problem before committing to a strategy.
2. **Choose** an appropriate mathematical model, given a description of real-world quantities.
3. **Choose** an appropriate mathematical model, given a data set.
4. **Analyze** and **interpret** real-world quantities or data, using the chosen mathematical approach.
5. **Defend** (verbally and in writing) the validity of various mathematical methods for a given task.
6. **Adapt** previously used methods to similar but new situations.
7. **Deploy** skills of algebraic manipulation in the context of modeling problems.
8. **Evaluate** whether a result is reasonable within the context of the original problem or data.
9. **Appreciate** and **enjoy** the power, practicality, and usefulness of quantitative tools for tackling problems.
10. **Develop confidence** in situations requiring quantitative reasoning and mathematical reasoning.

**Mathematical Skills**

1. **Translate** a verbal description of a function into a graph, table, or formula.
2. **Identify** the independent variable, dependent variable, domain, and range in the context of a word problem.

3. **Use** different types of functions (linear, exponential, logarithmic, power, polynomial, rational) for modeling. **Identify** and **interpret** key features of the graphs of these functions.

4. **Use technology** to analyze data and to evaluate the appropriateness of a model.

5. **Deploy** algebra skills to solve problems:
   a. **Simplify** algebraic expressions.
   b. **Factor** linear and quadratic equations.
   c. **Write** and **solve** inequalities.
   d. **Write** and **solve** systems of equations in two unknowns.
   e. **Manipulate, evaluate, and graph** relationships.
   f. **Solve** equations involving exponents.
   g. **Solve** equations involving logarithms.

6. **Analyze** a data set, using simple characteristics:
   a. **Explain** what the data set represents.
   b. **Graph** or **visualize** data that has been given non-graphically (e.g., in a table or as generated by a formula).
   c. **Compute** and **interpret** mean, median and mode.
   d. **Assess** and **justify** which of the mean, median, or mode is most or least useful.

**Assessments Developed**

Sample Midterm Exam 1

**Pedagogies Used**

The new course will incorporate active learning via group work, primarily in-class worksheet-style projects that students work on collaboratively. We hope to incorporate more inquiry-based learning into this course in the future.

**What assessments or documentation of impact were or will be used?**

*What measures were (or will be) used to monitor student learning related to the course transformation efforts? (e.g., attitudinal surveys, two-stage learning exams, pre-post course surveys, gains in learning on exams related to active learning activities, in-class participation ratings, faculty evaluations, case studies, student interviews, ratings of learning-level based on Bloom’s taxonomy, evaluation of student samples/work)*

The primary measure of whether the course achieves its’ goals is whether students are successful in follow-up courses: MATH 2510 (Intro to Statistics) or a discipline-specific statistics course such as PSYC 3101. We define success as passing these courses with a C or better. We will compare students taking MATH 1212 with those who enroll, instead, in College Algebra. We would also like to incorporate attitudinal surveys and some form of Student Assessment of Learning Gains.

**What were the results, if you have any?**

N/A - new course.
**How did you use or generate broader expertise and/or community in your work?**

*Expertise you drew on (yours, others)*

Tubbs has extensive experience teaching and mentoring undergraduates at CU, and developing new courses. Erica has taught the Mathematics Department’s “Introduction to Statistics” course twice, and has experience with the particular topics that students tend to struggle with the most in that course. Tenure-track faculty are not likely to teach or be involved with this course, and so they were not consulted in the design. Instructors are more likely to teach or coordinate the course, and we consulted with several such instructors (Liu and Manley) for their input.

(Rob Tubbs, please fill in detail about how the undergraduate committee, or a subset thereof, was involved in the course other than the approval of the proposal)

*Community built (within or across departments or institutions)*

We consulted with other members of the Mathematics Department, consulted with other (“client”) departments, and attended ShInDiG. Erica attended the national TRESTLE meeting, where she learned some details of course design, and made connections with STFs at other institutions (but these were not followed-up).

*Future plans or room for improvement in this area, or resources you wished you had*

Instructor buy-in to the active learning in the course will be important. (Rob Tubbs, do you have plans or ideas on how to create some buy-in, through community or idea sharing among instructors?)

It might have been nice to have clearer access to Math STFs and similar experts at other institutions, to get feedback on learning goals and worksheet design.

**How will you maintain the changes over time and across structures?**

*Location of Course Material Archive (how will others access your work?)*

It is in Google Drive currently, and will be transferred to the department archive once that exists. This is a structure that has worked for other courses, in which an informal archive is shared through Dropbox or Google Drive.

*Plan for Sustainability*

The course will be expanded from the pilot section to more sections in the future. Sustaining the active learning structures will be most challenging, and will rely in part on thoughtful teaching assignments (e.g., assigning instructors and graduate students who are open to trying the active learning techniques). We have brainstormed a list of more senior, pedagogy-interested graduate students who might be good candidates to teach the course the first semester of the official course. Rob Tubbs will teach the pilot semester in the Fall. We hope that by creating a set of materials that are well archived, it will create an expectation that future instructors will use the materials – and that it will be easier to use the developed materials than to create the course from whole cloth.

*Challenges for sustainability*
The greatest challenge for sustainability is the professional development of the lecturers and graduate students who teach the course. Getting buy-in from these teachers for active learning can be tough! The Math 5905 (Teacher Training for Graduate Students) course is a useful tool for getting graduate TA’s on board with active learning, but this course also changes a lot from year to year based on who teaches it.

What did and didn’t work well?

What worked well in the course itself?

TBD.

What worked well in the process of developing the course?

Both Erica and Rob have experience with related courses, as well as with backwards design and evidence based practice. Having weekly meetings to check in on progress and Google Docs to document the work was very helpful. Originally Erica thought that we might be able to accomplish more in the single semester, but plans were scaled back as it became clear how long it takes to develop materials, and when the proposal for the new course needed to be developed earlier than expected.

What could be improved in the course?

TBD.

What could be improved in the process of developing the course?

It would have been helpful to:

● Have the work last over two semesters: One planning semester and one pilot semester. This would enable the work to be more flexible (e.g., adjusting when the course proposal needed to be developed quickly), to establish some activities in advance of the course, and develop additional activities while the course was running.

● Pilot test some activities: If a traditional version of the course were running during material development, then activities could be pilot tested in that version. Or, if development occurred during a pilot semester, then activities could be tested and developed just-in-time, in response to feedback from students each week.

● Get feedback from national TRESTLE community: We got good feedback from local instructors, but could have used more feedback on worksheet design and learning goals from other STF-like people at other TRESTLE institutions.

● Have input from / knowledge of who will be teaching the course in the future.

● Not do the work during a dissertation semester.

Future Work

What are your open questions or concerns?

Is an inquiry-based course appropriate for this level of math course?
If we reduce emphasis on algebraic skills in this pre-requisite course, will students be successful in follow-on statistics courses?
What will you do in future semesters?

Erica is headed to a new job. Tubbs is teaching a pilot section of MATH 1212 in Fall 2016; Tubbs will also oversee a second pilot section to be taught by a Lecturer. Each of these sections will have small enrollments, of less than 20 students each. While teaching the course Tubbs will develop many of the active-learning materials for it and keep an extensive record of what worked and what did not work (as judged by material's ability to engage the students, the class discussion that follows the students engagement with the material, the students' performance on quizzes and exams, and whatever other assessment tools are appropriate). These assessment tools will be developed over the summer, before the course is first offered, in consultation with the UC Boulder TRESTLE PI and others. Because there will not be an LA or TA to support this work, Tubbs is hoping to get feedback on the course materials on an on-going basis from colleagues in the 'client' disciplines and, perhaps, through the local TRESTLE group.

In Spring 2017 another two, small-enrollment, pilot sections of MATH 1212 will be offered, using the materials from the Fall 2016 pilots that have been appropriately revised. Then in Fall 2017, College Algebra will not be offered and 8-10 sections of 30-35 students will be offered. These sections will be taught by a combination of graduate students and lecturers. These multiple sections will be coordinated by a single faculty member--all of the sections will use the same materials and assignments and have common midterms and final exams.