COLLABORATIVE DESIGN PROCESS

Brainstorm lesson contexts

Draft lessons

Language & literacy review

Quantway faculty review

Refinement

Lesson testing (Agile Cycle)

Industry faculty review
COLLABORATIVE DESIGN PROCESS

- **Brainstorm lesson contexts**
- **Draft lessons**
- **Lesson testing (Agile Cycle)**
- **Industry faculty review**
- **Quantway faculty review**
- **Language & literacy review**

Refinement flows through each step of the process.
The Problem

- Developmental mathematics in community colleges: “the graveyard of dreams and aspirations” (Merseth, 2011).
- Bailey, Jeong, & Cho (2010)
  - 60% of community college students take at least 1 development mathematics class
  - 80% of these students do not complete college-level mathematics course in 3 years

The Response

- Community College Pathways:
  - Statway®
  - Quantway®

- Goal of Quantway:
  - “Quantway is focused on quantitative reasoning that fulfills developmental requirement with the aim of preparing students for success in college-level mathematics. The goal of Quantway is to promote success in community college mathematics and to develop quantitatively literate students.” (Carnegie, 2015)
PROJECT AIM

“Assure that all students’ language and literacy levels allow them to understand problem situations, think and reason mathematically, and communicate results.”
NEW LESSONS

- Need compelling, authentic, and relevant problem situations for students entering diverse workforce domains.
- Convey that the mathematics, students are learning, in lessons really matter.
- Assure that all students’ language and literacy levels allow them to understand problem situations, think and reason mathematically, and communicate results.
WAYS WE ARE ADDRESSING THIS AIM:

10 New Quantway Lessons

Four New Healthcare Lessons

Four New Environmental Technology Lessons

Two New Information Technology Lessons
LIST OF CONTEXTUALIZED LESSONS

- **Healthcare**
  - Lesson 1.4: Affordable Care Act
  - Lesson 2.4: Picturing Healthcare Data with Graphs
  - Lesson 3.1: Acetaminophen Overdoses
  - Lesson 4.3: Understanding Heart Rate

- **Environmental Technology Lessons**
  - Lesson 1.8: Waste & Recycling
  - Lesson 2.3: Renewable Energy
  - Lesson 3.2: Solar Energy
  - Lesson 4.7: Rising Seas

- **Information Technology Lessons**
  - Lesson 2.7: How do Students Text?
  - Lesson 4.2: Trends in Social Media
DESIGN ELEMENTS OF QUANTWAY CONTEXTUALIZED LESSONS

- Authentic contexts in healthcare, environment sciences, & IT
- Language & Literacy Supports
- Agile Design & Improvement Process

New Quantway® Contextualized Lessons
LESSON 3.1: LESSON OBJECTIVES

Students will understand that

- the units found in a solution may be used as a guide to the operations required in the problem—that is, factors are positioned so that the appropriate units cancel.
- units provide meaning to the numbers they get in calculations.

Students will be able to

- write a rate as a fraction.
- use a unit factor to simplify a rate.
- use dimensional analysis to help determine the factors in a series of operations to obtain an equivalent measure.
**Problem Situation: Using Dimensional Analysis**

*Dimensional analysis* is a method of setting up problems that involves converting between different units of measurement. It is also called *unit analysis* or *unit conversion*. Many professionals—including pharmacists, dieticians, lab technicians, and nurses—use unit analysis. It is also useful for everyday conversions in cooking, finances, and currency exchanges. Many people can do simple conversions without dimensional analysis; however, they will likely make mistakes on more complex problems.

1. (a) According to Toyota's website, a 2013 Prius can get an estimated 51 mpg in the city and 48 mpg on the highway. How many miles will you be able to drive in the city if you have 4.5 gallons of gas?
   (b) How many gallons of gas will you need to drive 3,450 miles?
   (c) Your paycheck for two weeks came out to $1200. You work five days a week, 8 hours a day. How much are you making per minute in cents.

2. Many states have banned texting while driving because it is dangerous, but many people do not think that texting for a few seconds is that harmful. Suppose you are driving 60 miles/hour and you take your eyes off the road for 4 seconds. How many feet will you travel in that time?

   Start with the unit you are looking for, feet:

   $\rightarrow \text{ft}$

   Now, create a chain of ratios, starting with one where “ft” is in the numerator that will cancel all other units (hint: start with the fact that there are 5280 ft in one mile).
(3) In Module 2 we examined population densities and used these to calculated projected populations, given a population density but a different area. The population density of Tokyo is 4,050 people per square kilometer. Use dimensional analysis to calculate how many people would live in the nation of Japan, which comprises an area of 375,000 square km, if the entire nation was as dense as the city of Tokyo.

(4) Nurses are often required to calculate dosages. That is, they must check the order that a doctor has given for the administration of a drug and decide whether the dosage is correct. To calculate correctly they must convert between different metric units. For example, 1,000 milligrams (mg) = 1 gram.

Suppose a doctor has ordered a dose of 0.1 g of a medication. The drug comes in a solution concentration of 200 mg per mL. How many milliliters of this solution is required?
Problem Situation: Acetaminophen Confusion

Andy and Amanda are two new parents with a six-month-old little girl named Isabella. It is 2 a.m. Isabella just woke up crying. She has a fever of 102 degrees Fahrenheit. It is her first high fever. Andy and Amanda are worried. Amanda calls Isabella’s doctor to see if they should bring the baby to the emergency room. The doctor tells her to give Isabella acetaminophen (Tylenol®) to try to lower the fever before bringing the baby to the hospital.

The doctor prescribes a teaspoon of acetaminophen. (Acetaminophen is the active ingredient in Tylenol®.) Andy rushes to his local grocery store to buy medicine for Isabella. While at the store, Andy sees different types of acetaminophen.

He is confused (see Figure 1).
Isabella’s doctor did not specify the type of acetaminophen to use. Andy assumes the package would give the dose. But, the package only says to “consult a doctor” for children under 2 years. Andy notices two different types of acetaminophen for young children: children or infant acetaminophen. Andy thinks it might be a good idea to buy the infants’ type, because Isabella is a six-month-old infant.

Andy looks closely at the formula on the back of each box. The concentration amount of acetaminophen is different in each formula. The problem is that Andy is not sure what is best to give her. He does not know what a teaspoon is in milliliters (mL). He is worried he might give her too much or too little medicine.

In this lesson, you will use a Comprehension and Synthesis (CaS) Chart you used in lessons 1.4 and 2.4. Using the CaS Chart will help you have a deeper understanding of the problem situation. CaS Charts will help you understand the main issue(s) are that need to be resolved and to recognize what quantitative information is available to solve the problem.

(1) Read through the steps for completing the CaS Chart below before reading the problem situation. As you read the problem situation on your own, complete the CaS Chart. You may wish to return to these steps as you complete the CaS Chart.
(2) Which type of acetaminophen should Andy buy for Isabella? Is there any information missing that you need to be able to answer the question? Brainstorm possible answers with your group. Write your answer in 1-2 complete sentences. (It is important to write complete sentences because it helps your instructor better understand your mathematical thinking.)

(3) Answer the questions below. Show your calculations.
   (a) You have a 5-year-old patient, but only have the infant type of acetaminophen. How many mg of acetaminophen should the doctor prescribe for the 5-year old patient?
   (b) What is the concentration of the infants’ formula?
   (c) Based on this information, how many mL of infant acetaminophen should the doctor prescribe for the 5-year old patient?

(4) Let’s return to Andy and Amanda’s dilemma. At the grocery store, Andy calls the doctor but cannot reach him. Instead, Andy speaks to the on-call Advice Nurse. Imagine you are this Advice Nurse. You want to know how much medicine should be administered to Isabella. Isabella is a 6-month-old child who weighs 15 pounds (lb). The medicine comes in a liquid form. You will measure in teaspoons (tsp). The children’s concentration is 160 mg per 5 mL.

(5) Use dimensional analysis to calculate how many teaspoons (tsp) Andy should give Baby Isabella if he buys infants’ acetaminophen instead.
LESSON 2.3: LESSON OBJECTIVES

Students will understand that
• a relative change is different from an absolute change.
• a relative measure is always a comparison of two numbers.

Students will be able to
• calculate a relative change.
• explain the difference between relative change and absolute change.
Problem Situation: How the Census Affects the House of Representatives

Every 10 years, the United States conducts a census. The census tells how many people live in each state. You can also find how much population has changed over time from the census data. Census data is important for many reasons. Local governments may use this information about the rate of growth to plan for public services such as fire stations and schools. Another purpose of the census is to reapportion or divide the 435 U.S. House of Representative seats among the 50 states.

The **absolute change** in a state’s population tells by how many people the population has changed. The **relative change** is the change as it compares to the earlier population. Often relative change is given as a percentage. Use the following data for Questions 1–6.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware</td>
<td>900,877</td>
<td>783,600</td>
<td>117,277</td>
<td>0.15</td>
</tr>
<tr>
<td>Florida</td>
<td>18,801,310</td>
<td>15,982,378</td>
<td>2,818,932</td>
<td>0.18</td>
</tr>
<tr>
<td>Georgia</td>
<td>9,687,683</td>
<td>8,186,453</td>
<td>1,501,230</td>
<td>0.18</td>
</tr>
<tr>
<td>Maryland</td>
<td>5,773,552</td>
<td>5,296,486</td>
<td>477,066</td>
<td>0.09</td>
</tr>
<tr>
<td>North Carolina</td>
<td>9,535,483</td>
<td>8,049,313</td>
<td>1,486,170</td>
<td>0.18</td>
</tr>
<tr>
<td>South Carolina</td>
<td>4,625,364</td>
<td>4,012,012</td>
<td>613,352</td>
<td>0.15</td>
</tr>
<tr>
<td>Virginia</td>
<td>8,001,024</td>
<td>7,078,515</td>
<td>922,509</td>
<td>0.13</td>
</tr>
<tr>
<td>Washington, D.C.</td>
<td>601,723</td>
<td>572,059</td>
<td>29,664</td>
<td>0.05</td>
</tr>
<tr>
<td>West Virginia</td>
<td>1,852,994</td>
<td>1,808,344</td>
<td>44,650</td>
<td>0.02</td>
</tr>
<tr>
<td>South Atlantic Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For your group of states, calculate the absolute change in the population of each state.

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

List in order the three states that changed most in absolute population.

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

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

For the region you are given, calculate the absolute change in population from 2000 to 2010. Calculate the relative change in population between 2000 and 2010.
Problem Situation: Renewable Energy Generation

You just started a new job as an environmental researcher for a non-profit called the S&G Energy Association. The S&G Energy Association advocates for clean and sustainable sources of energy in your state. It is a local leader in environmental issues. As an environmental researcher, you study new policies and technologies used around the world. You create reports and presentations to talk about policies and technologies that could be used in your state.

Nearly 85% of the energy in the United States comes from fossil fuels. These fossil fuels include oil, natural gas, and coal. There are three main environmental concerns about fossil fuels as a source of energy. First, burning fossil fuels creates air pollution. Second, burning fossil fuels is a source of a large amount of CO₂ (carbon dioxide), which contributes to global warming. Finally, fossil fuels are limited resources. They were derived from fossils and take millions of years to form. We will eventually run out of fossil fuels.
### CONTEXTUALIZED LESSON 2.3: RENEWABLE ENERGY

*Figure 1: Change in renewable energy generation of electrical power between 2000 and 2010*

<table>
<thead>
<tr>
<th>Country</th>
<th>Renewable energy generation 2000 (measured in billion kilowatt hours)</th>
<th>Renewable energy generation 2010 (measured in billion kilowatt hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>361</td>
<td>440</td>
</tr>
<tr>
<td>Russia</td>
<td>165</td>
<td>168</td>
</tr>
<tr>
<td>Germany</td>
<td>41</td>
<td>110</td>
</tr>
<tr>
<td>Norway</td>
<td>140</td>
<td>117</td>
</tr>
<tr>
<td>Brazil</td>
<td>309</td>
<td>433</td>
</tr>
<tr>
<td>Canada</td>
<td>363</td>
<td>366</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>World</td>
<td>2872</td>
<td>4177</td>
</tr>
</tbody>
</table>
(1) Read through the steps for completing the CaS Chart below before reading the problem situation. As you read the problem situation on your own, complete the CaS Chart. You may wish to return to these steps as you complete the CaS Chart.

(2) Based on this data, which nation(s)' technologies and policies offer the most promising examples of renewable energy development and why? Write your answer in 1-2 complete sentences. It is important to write complete sentences because it helps your instructor better understand your mathematical thinking.

(3) Use Figure 1 to answer the following questions.
   (a) Calculate the absolute and relative change of Germany's renewable energy consumption from 2000-2010.
   (b) Calculate the absolute and relative change of Brazil's renewable energy consumption from 2000-2010.

(4) Based on the work above, predict how much renewable energy Germany will generate in 2020 using both absolute and relative change. Which prediction do you think makes more sense?

(5) Notice that Russia and Canada both increased their renewable energy generation by 3 billion kilowatt hours.
   (a) What does this mean about the absolute change in Russia's renewable energy generation from 2000 to 2010 compared to Canada’s?
   (b) Using a ratio, compare Russia's and Canada's relative change in renewable energy generation between 2000 and 2010. Perhaps asking whether 3 billion represent an absolute or relative change can be done first.
COLLABORATIVE DESIGN PROCESS

Brainstorm lesson contexts

Draft lessons

Language & literacy review

Quantway faculty review

Refinement

Industry faculty review

Lesson testing (Agile Cycle)
Unique features of our design process:

1. Our language and literacy review and the particular supports we have designed to increase access to the texts and discourses within developmental mathematics.

2. Our lesson testing process, which we call “The Agile Cycle,” which include lesson testing (really teaching of each lesson) and rapid design changes with faculty and students currently involved in Carnegie’s Quantway curriculum.
AGILE PROCESS GOALS

Testing and Improving Lessons:

• Language and literacy tools
• Main and supportive quantitative context
• PNLs (Prepare to the next Lessons) and OCEs (Out of Class Experience).
• Instructor’s Notes
• Timing
AGILE CYCLE: PRACTICE-FOCUSED & RAPID FEEDBACK TO IMPROVE DESIGN

Data for improvement

Teaching

Analysis & Revisions

Redesigned Lessons

Immediate Revisions
Overnight

Medium Revisions
1-2 weeks

Long term Revisions (months)
DATA SOURCES

- Videotaped lesson observations
- Student surveys
- Instructor surveys
- Instructor interviews
- Focus group interviews with students
- Analysis of student in- and out- of class work
AGILE PROCESS

Instructor 1 teaches lesson

Immediate Refinement

Instructor 3 teaches lesson

Immediate Refinement

Instructor 5 teaches lesson

Immediate Refinement

Instructor 7 teaches lesson

Medium Level Refinements

Long-term revisions (months later), formalize for broad-based implementation

Results in stable and usable lesson

Initial Lesson Design

Time
Examples of Changes to Instructors Notes
EXAMPLE 1: LESSON 1.4 AFFORDABLE CARE ACT

ANTICIPATING THAT STUDENTS WILL STRUGGLE WITH PERCENTAGES HIGHER THAN 100

**Note:** Students will likely struggle with using a percent that is greater than 100%. This may be a good place to talk about the PNL, where students worked on a problem with a percentage than 100. Point out that 150% can be expressed as 100% plus 50% of the poverty line, or 50% plus 50% plus 50%. The goal is for students to realize that 150% is 1.5 times the poverty line. If students are struggling, ask students what $11,670 represents as a percentage. Make sure they realize that $11,670 represents 100%.
Note: You may want to discuss the common mistakes students make with absolute and relative change. The most common mistake with absolute change is not using units, and the most common change with relative change is using the wrong reference value. Typically, students struggle most with relative change. You may want to do a mini-lesson using real-world numbers, such as rent, before moving onto question 3. Relative change is often a challenging concept for students to understand. Depending on your class, you may want to provide an outside example to introduce relative and absolute change with your students. Here is one possible example you could use with your class.

<table>
<thead>
<tr>
<th></th>
<th>Weight 2013</th>
<th>Weight 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat</td>
<td>12 lbs</td>
<td>16 lbs</td>
</tr>
<tr>
<td>Elephant</td>
<td>11,000 lbs</td>
<td>11,007 lbs</td>
</tr>
</tbody>
</table>
Examples of Changes to Mathematical Problems in the Lessons
(7) As parents to an infant, Andy and Amanda must consider what to feed Isabella. For newborns, there are two different types of formula: a ‘Ready-to-Feed’ liquid, and a powder formula. Formula is very expensive. Andy and Amanda must calculate the cost for each formula to determine which one fits their budget. They must feed little Isabela every 3 hours, and each feeding is 140 mL. Remember, 1 ounce = 30 mL.

(a) The ‘Ready-to-Feed’ liquid costs $8 for 32 ounces of formula. What is the cost of using the ‘Ready-to-Feed’ formula for 1 month?

(b) The powdered formula is $32 for 1 container of powder. This makes 169 ounces of formula when mixed with water. What is the cost of using the powdered formula?

Note: As a class, discuss which formula would be cheaper for Andy and Amanda. Ready-to-feed formula is more convenient to use but it is $68 more expensive (or 32% more) each month than the powdered formula.
EXAMPLE 4. LESSON 2.4  PICTURING HEALTHCARE DATA WITH GRAPHS

CHANGING GRAPHS: A MORE READABLE SCALE

*Charts are based on data from the Center of Disease Control: http://www.cdc.gov/nchs/data/hestat/obese/obese99.htm.*
WHY LITERACY TOOLS?

• Long, overwhelming problem situations
  o Limited proficiency
  o Non-native speakers

• Students struggle
  o Staying organized
  o Grasping big-picture

• They lack effective tools
LITERACY TOOLS

- Annotation
- Double-entry journal
- Comprehension & Synthesis Chart (CaS)
WHAT IS IT?

• Three main parts:
  A: Main Issue

**Part A:** What is the dilemma or main issue in this problem situation?
WHAT IS IT?
• Three main parts:
  A: Main Issue
  B: Relevant Info

Part A: What is the dilemma or are the main issue(s) in this problem situation?

Part B: What quantitative information is important to address the issue?
WHAT IS IT?

• Three main parts:

A: Main Issue
B: Relevant Info
C: Plan

Part B: What quantitative information is important to address the issue?

Part C: Describe how you might use the info in Part B to approach the issues in part A
HOW IS IT USED?

• Introduced First
  o Stand-alone mini-lesson during QW 1.3
  o Promoted: tool to organize & communicate
  o 1<sup>st</sup> Independent reading
  o 2<sup>nd</sup> Team brainstorming
  o 3<sup>rd</sup> Group wrap-up discussion

• Use built into later QW lessons

• Always available as optional tool
THANK YOU

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