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# Recipes for Understanding: Foundations of Fractions, Ratios, and Proportions

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## Introduction/Rationale

It was a familiar scene in my high school special education math resource classroom. I had a small group of students at my table working on a new concept while the rest were working independently on what was supposed to be review material in the district-provided online intervention program. Within a few minutes, most of the students had disengaged from their computers. Some were clicking at a rapid pace that indicated they were not even reading the questions. Some had put their heads down and gone to sleep. Others had strayed into other activities all together. A precious two still stared at their screen bewildered and one slowly raised her hand. “Miss, this has fractions. You know we can’t do fractions.” And unfortunately, I did know. I have been teaching high school math in the resource setting for eight years and while each group, and each student, have their own strengths and weakness, fractions are consistently a weakness for them all.

Extending beyond just the concepts of fractions, performing basic operations, comparing fractions, and determining equivalent fractions, students are asked to apply this principle to advanced math concepts such as ratios and proportions like slope (rate of change) in Algebra and dilation of figures in Geometry. They are being asked to learn new concepts on an incomplete base of knowledge. Some of them have been able to memorize “tricks” like the butterfly method for filling in the missing part of equivalent fractions, but don’t understand the concept enough to have set up that equation or proportion for themselves. It is also important to talk about fractions and ratios in some of the same conversations because they are not exchangeable words for the same concept but often looked at in the same way because of how they are sometimes represented. By exploring them both within the same unit, we are able to make the distinction, discuss their relationships, and hopefully prevent some of the confusion that comes when introduced separately.

Combining my own observations with those of other math and science colleagues on my campus, it has become apparent that I need to take a direct approach to teaching these concepts and help students to apply them to their grade-level studies. This unit will address the target skills and concepts through both hands-on activities and models experienced in real life. These activities will “support applied mathematics as essential for promoting quantitative literacy and improving mathematics performance, as food is an effective teaching tool for engaging students in retaining information about multidisciplinary concepts.”[1]

This unit was written to serve special education grade 10 and 11 math resource students at Rudder High

School in Bryan ISD in Texas, a campus serving approximately 1,700 students with a distinct demographic profile: roughly 65% Hispanic, 18.5% African American, and 14% White.[2] Notably, up to 81% of the student body is classified as economically disadvantaged, 31% are Emergent Bilingual students, and over 16% receive Special Education services. Campus state assessment data reveal significant gaps in traditional mathematical proficiency, indicating there is an urgent demand for responsive, equity-minded pedagogy. By utilizing a high-engagement, multi-sensory cooking curriculum, this unit directly serves Rudder's diverse population by removing language barriers, contextualizing abstract concepts for specialized learners, and providing immediate, tactile feedback that traditional worksheets fail to offer. Anchoring mathematical instruction in practical contexts offers a dual advantage for learners with disabilities or significant academic gaps. By connecting structural concepts to tangible, real-world experiences, students achieve greater long-term retention. Furthermore, these learners demonstrate superior performance on standard abstract assessments compared to peers utilizing traditional, worksheet-based methods.[3]

## Content objectives

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Teachers will need a firm understanding of fractions, ratios, and proportions and the ways these concepts relate to cooking before teaching this unit. This section provides information and explanations to fortify existing knowledge and hopefully expand how they think about these concepts.

**What are fractions?**

A common explanation of fractions is a mathematical representation of parts of a whole or parts of a set. But in truth the typical  can represent so much more. It can indeed indicate parts of a whole (slices of pizza) or parts of a set (how many red marbles in the bag). But it can also illustrate points on a number line, a ratio, a division problem, or an operator. In the special education classroom, students' experiences with fractions will range and even if they have been exposed to all of these concepts, they may not have a firm grasp on any of them.

Let's look at the basic structure of a fraction, . The line in the middle is the fraction bar. The number on top, represented here by a, is the numerator and generally is thought of as the 'part' being considered. The number on the bottom, represented here by the letter b, is the denominator and generally is the of as the number of equal parts or number of elements in the set. For example,  of a pizza would indicate that the pizza was cut into four equal slices and we are taking or considering three of them. This illustration is an example of an area model and can be thought of when visualizing that pizza cut into equal slices. A set model is used when examining a situation like  of the students are wearing green shirts today. The number 5 in the denominator position tells that there are five individuals (nothing is "cut" into 5 pieces) and the 2 in the numerator tells that two of them are wearing green.

Fractions can also be illustrated on a number line, but the thinking needs to be adjusted just a little. Fractions on a number line describe their position on the line and its distance from zero. When representing a number greater than zero, but less than one, it will be located between zero and one. That interval will be divided into equal sections, as indicated by the denominator. The numerator then tells how many of those section to count from zero. The number line can also be a valuable tool when demonstrating the relationship between fractions and decimals. The number 0.4 is read as four tenth and can be expressed as  . On a number line, the interval

between zero and one is partitioned into 10 equal parts and then the student travels four of those parts from zero.

There is a common misconception among many students when comparing fractions. The assumption is often made that a larger denominator denotes a larger fraction, such as saying  is greater than  because 8 is greater than 4. This concept can be easily demonstrated and the misunderstanding corrected by showing how the same size "whole" divided into more equal pieces results in all the pieces being smaller.  In cooking, fractions are used for measuring ingredients, dividing servings, scaling recipes, and comparing ingredient amounts.

Quantities larger than one can be represented using improper fractions or mixed numbers. Improper fractions are fractions in which the value of the numerator is greater than the value of the denominator. A mixed number is the combination of a mixed number and a proper fraction. Many students will not realize that improper fractions and mixed numbers may represent the same values. This can be illustrated through the cooking when measuring and combining ingredients.

Improper fractions and mixed numbers can be represented with number lines, area models, fractions strips, measuring cups, recipe scaling, and repeated addition of unit fractions. A common misconception to look out for may surface when scaling recipes. They may see  as impossible rather than understanding it as 1 and . Improper fractions may appear when recipes are multiplied or divided when scaling them for various groups.

Professional bakers tend to work with the weight of an ingredient like flour and discuss it as percentages rather than measuring cups which are often fractional values. Using weight makes them easier to compare and scale.[4] Many bakers will develop formulas by determining the proper ratios of ingredients before converting them to weights. This is a great discussion to have with students in algebraic reasoning to reinforce how we can write our own formulas to solve daily problems.

**What is a ratio?**

Ratios often get confused with fractions because they are also often represented as . But when used in this context, instead of representing parts of a whole, it is representing the comparison of two quantities. For example, 1 cup water and 2 cups flour is represented by the ratio 1:2 or also written as . In this example, the 'whole' actually has 3 parts (1 water + 2 flour). Cooking provides an example way to emphasize this distinction as the teacher can show the three individual cups, one with water and two with flour. There are many ratios in cooking for things like dough or sauces. Other ingredients may be added to influence taste or texture, but the general ratio usually stays the same.[5]

Changing the ratio of ingredients will change the final outcome when cooking. This is easily observable in the role of baking soda or baking powder. Both of these ingredients produce carbon dioxide, causing dough to rise. Too little and the finished product will be dense and flat. Too much and the finished product will have a bitter taste and may collapse.

The ratio of flour to water is another situation students may be familiar with, even if they don't know it. Cakes, cookies, and pancakes all have ratios of flour and water but are very different foods because of not only additional ingredients, but the ratio of flour to water within them. Flour contains proteins that when combined with water, create gluten. Changing the ratio of flour to water causes changes to elasticity, viscosity, chewiness, and structure of the dough.

The water and oil in salad dressings will eventually separate due to their chemical properties, regardless of their ratio to each other. Water is hydrophilic (water loving) while oil is hydrophobic (water fearing). This effect can be altered by adding an emulsifier in a specified ratio to the other ingredients, such as an egg yolk which contains lecithin that is amphiphilic (having both water loving and water fearing properties).

**What is a proportion?**

Proportions describe the equality of equivalent ratios or fractions. They represent that while the overall quantities may change, their relationships to each other (or ratio) will not change. In cooking we often use proportions to determine a missing value when there is an unknown. For example, if the recipe says that it serves 6 but we have 12 people coming for dinner, every ingredient must be multiplied by 2. () They can also be used to find a missing value, such as  could represent “If a recipe has a ratio of 1 part water to 2 parts flour, how much water would need to be added to four cups of flour?” Some students will remember that “butterfly method” they learned in middle school, but often will not understand the relationship. Students are taught to circle the diagonal pairs, creating a “butterfly” image. Then to multiply them, creating a one variable equation. So  would become .

Proportions are not just about making recipes bigger or smaller. They are about keeping the relationship between the quantities. The amounts change, but their relationships do not. Much like the independent and dependent variables of functions we talk about in algebra and algebraic reasoning, the ratios of the ingredients remain the same.

Properly scaling a recipe preserves the chemical interactions between the ingredients. If students make mistakes, the interactions and the resulting food will change. This is a direct illustration of the chemistry of the ingredients and their relationships with each other.

Fractions, ratios, and proportions provide the mathematical foundation for understanding the relationships between ingredients in a recipe, while chemistry explains why those relationships matter. Throughout this unit, students explore how changing ingredient ratios affects physical and chemical properties such as gluten development, gas production, emulsification, and texture. Rather than learning these as abstract mathematical concepts, students apply them to authentic cooking situations where they can predict outcomes, test their ideas, and observe the results firsthand. By connecting mathematics and chemistry through a familiar, real-world context, students gain a deeper conceptual understanding of proportional reasoning while recognizing that mathematics is a practical tool for explaining and predicting the world around them.

## Teaching Strategies

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Since my current class is a special education resource level classroom, I chose teaching strategies that provide a variety of support and adapt with students.

Concrete-Representational-Abstract (CRA) instruction will allow students to explore the mathematical concepts through hands-on activities using measuring cups, recipe cards, and cooking demonstrations before moving on to models and manipulatives. The teacher will then have concrete examples of the symbols and representations to refer back to when students need clarification.

Explicit Instruction (I do, we do, you do) will be essential throughout the unit. Teachers need to model, guide, and gradually release students not only with the math tasks, but in using cooking tools, filling out reports, and other activity related tasks. This strategy provides students with the support they need while learning new and challenging concepts. They will be building on prior knowledge and making connections while moving through modeled and guided practice. Then, they will have the opportunity to try it on their own and receive feedback before misconceptions become ingrained.

Error Analysis is naturally included in this unit because cooking provides immediate, meaningful consequences for mathematical errors. Students identify common misconceptions, justify their reasoning, and develop a deeper understanding of mathematical concepts through activities that contain intentionally incorrect calculations or ingredient measurements and correct the mistake to “fix” the outcome.

Cooperative Learning happens easily through cooking. Students are excited to not be doing notes and worksheets and by the possibility of snacking on their work. Through guided discussions, students will discuss predictions, calculations, and observations while working together. Each student contributes in the ways they are able with their varied strengths and abilities.

Real-Life problem-solving makes cooking the context for the application of fractions, ratios, and proportions while allowing students to observe mathematical decisions to everyday situations. Students are able to see that changing mathematical relationships directly influences the outcome of a recipe, reinforcing both conceptual understanding and the relevance of mathematics beyond the classroom.

Differentiation and scaffolding are incorporated throughout this unit to provide students with the support they need while maintaining high expectations for mathematical thinking. Because students enter the classroom with varying levels of background knowledge and mathematical proficiency, instruction is designed to provide multiple pathways for accessing the content without reducing its complexity. Scaffolds such as visual models, graphic organizers, vocabulary supports, guided notes, chunking multi-step problems, and teacher think-alouds help students organize their thinking and develop conceptual understanding. Hands-on materials, including measuring cups, measuring spoons, and recipe cards provide concrete representations of abstract mathematical concepts before students transition to symbolic representations. As students gain confidence and demonstrate understanding, these supports are gradually removed, encouraging increasing independence while ensuring that all students have opportunities to successfully engage with fractions, ratios, proportions, and the chemistry concepts explored throughout the unit.

## Classroom Activities

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**Section One: Measuring matters**

Students begin the unit by developing a conceptual understanding of fractions through the use of standard kitchen measuring tools. Rather than introducing fractions solely as numerical symbols, students explore them as measurable quantities by using measuring cups and measuring spoons to measure both liquid and dry ingredients. Students compare the relative sizes of common fractions, identify equivalent fractions, and investigate improper fractions and mixed numbers within authentic cooking scenarios. For example, students may determine how to measure one-half cup when only a one-fourth cup measuring cup is available or explore multiple ways to measure one and one-half cups using different combinations of measuring tools.

Throughout these investigations, students make observations about the relationships among fractions while developing fluency with equivalent fractions, fraction comparisons, and conversions between improper fractions and mixed numbers. These hands-on experiences provide the concrete foundation needed for later work with ratios and proportions.

The opening activity prepares Trail Mix where everything can be measured easily, and students work with fractions of cups rather than navigating through cups, teaspoons, tablespoons, etc. Students compare part to part and part to whole relationships. Mathematically, students measure fractional quantities, identify equivalent fractions, compare quantities, and even begin discussions to scale a recipe.  Quantities can be represented with measuring cups, fraction strips, visual models, number lines, rations, and tables.

**Section Two: Ratios in Recipes (biggest chemistry tie in)**

Students investigate how ratios influence both the mathematics and chemistry of cooking by exploring the relationships among ingredients in familiar recipes. The unit begins with a simple example, such as lemonade, allowing students to examine how changing the ratio of lemon juice, water, and sugar affects concentration, flavor, and overall quality. Before making changes, students predict how altering a single ingredient will affect the final product and justify their reasoning mathematically. Students then calculate the new ratios, prepare or observe the modified recipes, and compare their predictions to the observed outcomes. Additional investigations may examine how changing ingredient ratios affects properties such as texture, gluten development, gas production, or emulsification in other recipes. Through these activities, students discover that recipes are built on carefully balanced relationships and that changing one ingredient without adjusting the others alters both the mathematics and the chemistry of the finished product.

Begin the activity with the baseline ratio of ingredients for a traditionally tasting lemonade. Students are required to identify the original quantities of each ingredient and express those quantities as ratios. Then students are allowed to explore by changing one variable, connecting to the processes in science experiments where only one variable can be changed at a time in order to conduct a controlled investigation. This is also an appropriate time to discuss additive versus proportional changes. For example, if a recipe calls for 1 cup of lemon juice and 4 cups of water, adding another cup of juice does not mean we have doubled the recipe. Only doubling one ingredient will change the ratio and change the flavor of the finished product.

There are several conversations to have with this portion of the unit that tie what they are learning in math back to concepts they have discussed in chemistry. Adding more lemon juice increases the acidity and produces a more concentrated and sour flavor. Increased water will dilute the solution, lowering the concentrations of the other ingredients.

This activity is a great opportunity to look at equivalent ratios. Students need to understand that a recipe can look different mathematically while remaining chemically and mathematically equivalent. For example, 1:4 can be multiplied by 2 to become 2:8. The recipe now has more ingredients, but the relationships have not changed.

**Section Three: Scaling a recipe with proportions**

Students apply proportional reasoning by scaling recipes to serve different numbers of people while maintaining the original ingredient relationships. Working individually or collaboratively, students select a recipe and determine the appropriate scale factor needed to prepare the recipe for various situations, such as feeding a family of four, preparing enough food for the entire class, or serving a large community event.

Students calculate new ingredient amounts, convert improper fractions to mixed numbers when appropriate, and explain how maintaining proportional relationships preserves the intended chemical interactions among ingredients. Throughout the activity, students justify their calculations, compare solution strategies, and discuss how changing only one ingredient would affect the final product. This activity reinforces the distinction between ratios, which describe the relationships within a recipe, and proportions, which preserve those relationships when the recipe is scaled.

A recipe that fits this concept with a great tie in to chemistry is making a simple vinaigrette dressing. Most students have likely seen how oil and water do not mix, but may not make the immediate connection to vinegar and water. This can be quickly and easily demonstrated with a small amount of each so that students understand what property they are changing with the addition of an emulsifying ingredient. A basic vinaigrette can be made with 3 tablespoons oil, 1 tablespoon vinegar, ½ teaspoon mustard, and salt/pepper. Students simply measure the ingredients into jars and shake. The starting ratio is three parts oil to one part vinegar. Groups can make different versions by changing the ratio – 2:1(more acidic), 4:1 (more oil), 1:1 (dramatically different), and one without the mustard. The last one is useful because the mustard acts as an emulsifying aid, keeping the oil and vinegar mixed. Without an emulsifying agent, the oil and water will separate if left standing. Students will answer not only questions about the ratios, but about their observations of how changing the ratio changed how well the ingredients stayed mixed.

**Section Four: Unit rates**

Students explore unit rates through an authentic budgeting activity that connects mathematics to everyday decision making. After selecting a recipe, students research current prices of ingredients using local grocery advertisements, store websites, or online retailers. Students determine the quantity of each ingredient required for the recipe, calculate the cost of the portion used, and use unit rates to compare prices among different package sizes when appropriate. Students then determine the total cost of preparing the recipe and calculate the cost per serving. Additional extension activities may include comparing homemade recipes to commercially prepared alternatives or identifying the most economical purchasing options. This investigation reinforces proportional reasoning while demonstrating the practical applications of unit rates in budgeting, meal planning, and consumer decision making.

This activity can be expanded by having students apply their math skills to make consumer decisions. Give students a realistic budget and pose the question “You have $15 to make a snack for 15 people. Which ingredients and packages sizes will allow you to stay within your budget?” Students have to make decisions rather than just perform calculations. The scenario could be further varied with slight changes to the scenario: feed 4 people for $10, feed 8 people for $20, choose the cheapest option, choose between two stores, etc.

**Section Five: Recipe conversions**

Students develop their skills converting among common units of measurement used in cooking, including teaspoons, tablespoons, cups, pints, quarts, and gallons. Because accurate measurement is essential in both cooking and chemistry, students investigate how incorrect unit conversions can alter ingredient ratios and affect the outcome of a recipe. Through guided practice and authentic recipe scenarios, students convert measurements while explaining the mathematical relationships between units. Students also determine the most efficient measuring strategies when given limited measuring tools and discuss why accurate measurement is particularly important in baking and laboratory settings. This activity reinforces multiplication, division, fractions, and proportional reasoning while highlighting the importance of precision in scientific investigations.

To challenge students in this section, limit their access to measurement tools. For example, give them only 1 cup, ½ cup, and 1 tablespoon. Then give them a recipe requiring 1 ¾ cups of water, 3 tablespoons lemon juice, and 2 teaspoons sugar. They will need to understand the relationships between fractions and how make conversions between various units. Once they are comfortable making these conversions in the context of food and cooking, the skill can be converted to their chemistry class where they are frequently needing to convert between different units.

**Final Activity: Recipe Rescue**

The final activity challenges students to synthesize the mathematical concepts developed throughout the unit by serving as "recipe detectives." Students are presented with recipes containing intentional mathematical errors, such as incorrect fraction calculations, improper unit conversions, inaccurate recipe scaling, or altered ingredient ratios. Working individually or in small groups, students identify each error, explain the mathematical misconception, correct the calculations, and predict how the mistake would affect the chemistry and quality of the finished product. For example, students may determine what would happen if only the flour were doubled while the remaining ingredients remained unchanged or identify the consequences of using an incorrect unit conversion. Students justify their reasoning using appropriate mathematical vocabulary and their understanding of the chemistry of cooking. This performance task provides an authentic opportunity for students to demonstrate conceptual understanding of fractions, ratios, proportions, unit rates, and measurement while applying mathematical reasoning to real-world situations.

## Resources

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Bottge, Brian. “Contextualized Math Helps Students Improve Skills – UW–Madison News – UW–Madison.” University of Wisconsin-Madison, November 15, 1999. https://news.wisc.edu/contextualized-math-helps-students-improve-skills/.

Article professor of rehabilitation psychology and special education exploring how low and average performing students improve their performance on standardized tests after learning and practicing math skills through conceptualized projects

Gisslen, Wayne, essay, in *Professional Cooking* (Hoboken: Wiley, 2025), 24–26.

Houston Public Media, and Acacia Coronado. “Texas Tribune Schools Explorer: James Earl Rudder High School.” The Texas Tribune, July 31, 2026. https://schools.texastribune.org/districts/bryan-isd/james-earl-rudder-high-school/.

Website used to find basic demographics of target school

Roseno, Ashley T., Virginia G. Carraway-Stage, Callan Hoerdeman, Sebastián R. Díaz, Eugene Geist, and Melani W. Duffrin. “Applying Mathematical Concepts with Hands-on, Food-based Science Curriculum.” School Science and Mathematics 115, no. 1 (January 5, 2015): 14–21. https://doi.org/10.1111/ssm.12097.

Journal article describing the implementation of specific food and cooking based curriculum in multiple schools.

Ruhlman, Michael. Ratio: The simple codes behind the craft of everyday cooking. New York, New York: Simon & Schuster Audio, 2023.

A book about common ratios in cooking that can be adapted for multiple recipes

## Appendix on Implementing District Standards

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My students are enrolled in specific courses, but almost all lack many of the same basic math understanding. I will be using this unit with students enrolled in Foundational Algebraic Reasoning and Foundational Geometry to bridge gaps in these areas.

For students in Algebraic reasoning, the unit specifically addresses essential concepts by focusing on bivariate patterns, constant rates, and functional relationships.

- AR.2(A) / AR.2(B) - Modeling and Representing Linear Relationships:
    - Creating lemonade establishes a tangible connection for linear modeling. Maintaining the balance between water and sugar illustrates predictable growth: doubling the liquid requires doubling the sweetener to preserve the ratio.
    - Students transition from concrete recipes to abstract mathematical representations. By documenting measurements in tables and graphs, they derive the algebraic equation, where the specific flavor profile represents the constant of proportionality.
- AR.2(D) - Solve problems using linear equations:
    - Adjusting recipe yields provides a direct application for solving unknown variables. Determining the necessary multiplier to increase a serving size from 4 to 12 allows students to solve for x within a practical context.

For students in Geometry, the mathematical principles of scaling ingredients mirror geometric dilations and similarity, creating a roadmap to higher-level geometric concepts through culinary application.

- G.7(A) - Understand similarity in terms of similarity transformations (Dilations):
    - Modifying recipe sizes functions as a non-rigid transformation. While the scale factor alters the total quantity, the underlying proportions of ingredients must remain constant to preserve the integrity of the flavor profile.
    - This anchor allows for the explicit introduction of the term Scale Factor. Just as multiplying triangle dimensions by two creates a similar but larger shape, doubling a recipe uses the same mathematical logic to increase volume while maintaining similarity.
- G.10(B) - Effects on perimeter, area, and volume when dimensions are multiplied by a scale factor:
    - The cookie analysis highlights the impact of broken ratios, such as failing to scale eggs proportionally. Furthermore, expanding a cookie cake’s dimensions demonstrates how volume requirements increase cubically rather than linearly.

## Notes

[1] Ashley Roseno, et al “Applying Mathematical Concepts with Hands-on, Food-based Science Curriculum.” School Science and Mathematics 115, no. 1 (January 5, 2015): 14–21. https://doi.org/10.1111/ssm.12097.

[2] Houston Public Media, and Acacia Coronado. “Texas Tribune Schools Explorer: James Earl Rudder High School.” *The Texas Tribune*, 31 July 2026, schools.texastribune.org/districts/bryan-isd/james-earl-rudder-high-school/.

[3] Bottge, Brian. “Contextualized Math Helps Students Improve Skills – UW–Madison News – UW–Madison.” University of Wisconsin-Madison, November 15, 1999. https://news.wisc.edu/contextualized-math-helps-students-improve-skills/.

[4] Wayne Gisslen, essay, in *Professional Cooking* (Hoboken: Wiley, 2025), 24–26.

[5] Ruhlman, Michael. Ratio: The simple codes behind the craft of everyday cooking. New York, New York: Simon & Schuster Audio, 2023.

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