

Getting Started with the CandyDepot Educational Game

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Purpose of CandyDepot

Introduction

CandyDepot is an educational mathematics game for the iPad that invites players to work their way up the corporate ladder by managing the shipping department at Candy Inc.. Players must work quickly and efficiently if they hope to impress the ever-grumpy Boss Cog!

Background & Purpose

CandyDepot is the second in a series of transformative apps designed to enhance mathematics education for later elementary and middle school students. The first in the series, *CandyFactory*, focuses on understanding and manipulating fractions. *CandyDepot* focuses on a critical pre-algebraic mental activity referred to as *units coordination*.

Learning Objectives

Students' ability to coordinate multiple levels of units aids their ability to understand mathematical concepts. Students who can coordinate two levels of units in activity can solve simple multiplication problems, like 4×6 , by counting by 6 four times. However, such students cannot necessarily understand situations involving more than one set of 6s and would not deduce that 4×6 and 3×6 is simply 7×6 . In order to meaningfully understand such situations, students need to organize two levels of units as a structure in which they can think about four 6's and three 6's as objects that can be acted upon. Likewise, organizing three levels of units opens possibilities for students to meaningfully assimilate numerous situations across content domains: whole number multiplication, integer addition, fractions concepts, and algebraic reasoning.

CandyDepot should help teachers and students meet the following learning objectives:

- Students who can coordinate only two levels of units in activity should organize that activity as a mental structure for assimilating two levels of units.
- Students who can coordinate three levels of units in activity should organize that activity as a mental structure for assimilating three levels of units.
- Students who have already developed a structure for assimilating three levels of units should learn how to productively apply that structure to solving tasks involving fractions.

CandyDepot Levels and Learning Progression

Game Narrative

Upon entering the *CandyDepot*, the benevolent President Carmello fast tracks you for promotion. She informs you that you are now responsible for distributing candy bars to Candy Inc. customers around the United States. To prove your worth, you must package and ship the correct number of candy bars to fill customer orders. The challenge is to efficiently ship each order using the fewest number of components—bars, bundles, and boxes—as possible.

At Level One, you must first choose how many bars go in each bundle and how many bundles go in each box. These choices will determine possibilities for fulfilling customer orders for specified numbers of bars, bundles, and boxes (including fractions of bundles and boxes!). Your performance will be rated by how efficiently you fulfill each order. The fewer bars, bundles, and boxes you use to fill an order, the higher your efficiency rating.

At Level Two, you are allowed to preview the orders that will be placed. Identifying common factors between the orders will allow you to efficiently choose the number of bars in each bundle and bundles in each box. Again, the fewer bars, bundles, and boxes you use to fill the orders, the higher your efficiency rating.

After each shift, a detailed shift log will provide you with feedback to assess your progress. You can also earn bonus cash and trophies for correct orders and fast turnaround. Your bonus cash can be used to customize your workspace, change the types of packages you use, or even give Boss Cog a funny hat! You can replay levels to beat your best scores or turn off the shift clock to practice unrestricted.

Game Play and Educational Considerations

- *CandyDepot* incorporates candy bars, bundles, and boxes to promote units coordination
- Game play is enhanced through the use of bonuses and achievements to encourage students to replay levels until they master the underlying principles
- *CandyDepot* features a colorful interface with large gaming elements to enhance game interaction
- Simple game gestures (physics) are incorporated in an effort to satisfy universal design considerations

Mapping the Common Core State Standards for Mathematics to *CandyDepot*

Grade 4

- **Gain familiarity with factors and multiples.**
 - [CCSS.Math.Content.4.OA.B.4](#) Find all factor pairs for a whole number in the range 1–100. Recognize that a whole number is a multiple of each of its factors. Determine whether a given whole number in the range 1–100 is a multiple of a given one-digit number. Determine whether a given whole number in the range 1–100 is prime or composite.

Beginning in Level One of CandyDepot, students create units of units (of units) by which they can come to recognize various relationships between factors and multiples.

- **Use the four operations with whole numbers to solve problems.**
 - [CCSS.Math.Content.4.OA.A.1](#) Interpret a multiplication equation as a comparison, e.g., interpret $35 = 5 \times 7$ as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations.

Students will engage in multiplicative size comparisons throughout Levels 1 and 2 of CandyDepot through the bundling and boxing procedures.

- [CCSS.Math.Content.4.OA.A.2](#) Multiply or divide to solve word problems involving multiplicative comparison, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem, distinguishing multiplicative comparison from additive comparison.

Students can “draw out” the bars within the bundles within the boxes, by which they could coordinate units in activity.

- [CCSS.Math.Content.4.OA.A.3](#) Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.

Efficient bundling and boxing in Level 2 of CandyDepot involves anticipation of the utility of particular bars to bundle ratios and bundle to bar ratios that results from reflection on activities of estimation, rounding, and adjustment for remainders.

Grade 5

- **Apply and extend previous understandings of multiplication and division.**
 - **CCSS.Math.Content.5.NF.B.5** Interpret multiplication as scaling (resizing), by:
 - **CCSS.Math.Content.5.NF.B.5a** Comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication.

Students will engage in multiplicative size comparisons throughout Levels 1 and 2 of CandyDepot through the bundling and boxing procedures.

- **CCSS.Math.Content.5.NF.B.5b** Explaining why multiplying a given number by a fraction greater than 1 results in a product greater than the given number (recognizing multiplication by whole numbers greater than 1 as a familiar case); explaining why multiplying a given number by a fraction less than 1 results in a product smaller than the given number; and relating the principle of fraction equivalence $a/b = (n \times a)/(n \times b)$ to the effect of multiplying a/b by 1.
- **CCSS.Math.Content.5.NF.B.6** Solve real world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem.

Students will solve problems involving multiplication and division of fractions in both Levels 1 and 2 of CandyDepot, when the game asks for orders in terms of a fraction of boxes or bundles.

Grade 6

- **Understand ratio concepts and use ratio reasoning to solve problems.**
 - **CCSS.Math.Content.6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes."*
 - **CCSS.Math.Content.6.RP.A.3d** Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Success in CandyDepot involves students' developing a flexible understanding of the relationships between the unit ratios between bars and bundles, bundles and boxes, and bars and boxes.

- **CCSS.Math.Content.6.RP.A.2** Understand the concept of a unit rate a/b associated with a ratio $a:b$ with $b \neq 0$, and use rate language in the context of a ratio relationship. For example, “This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is $3/4$ cup of flour for each cup of sugar.” “We paid \$75 for 15 hamburgers, which is a rate of \$5 per hamburger.”¹
- **CCSS.Math.Content.6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

Students can go back to look at unit rates throughout CandyDepot, i.e., to revisit how many bars are in a bundle, or how many bundles are in a box. The story line of the game involves a real-world scenario of efficient shipping.

Grade 7

- **Analyze proportional relationships and use them to solve real-world and mathematical problems.**
 - **CCSS.Math.Content.7.RP.A.1** Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. For example, if a person walks $1/2$ mile in each $1/4$ hour, compute the unit rate as the complex fraction $1/2 / 1/4$ miles per hour, equivalently 2 miles per hour.

Success in CandyDepot involves students’ developing a flexible understanding of the relationships between the unit ratios between bars and bundles, bundles and boxes, and bars and boxes.

- **Apply and extend previous understandings of operations with fractions**
 - **CCSS.Math.Content.7.NS.A.3** Solve real-world and mathematical problems involving the four operations with rational numbers.

Students will solve problems involving multiplication and division of fractions in both Levels 1 and 2 of CandyDepot, when the game asks for orders in terms of a fraction of boxes (or bundles).

Virginia Standards of Learning for Mathematics Addressed by *CandyDepot*

Grade 4

4.4 The student will

- a) estimate sums, differences, products, and quotients of whole numbers;
- b) add, subtract, and multiply whole numbers;
- c) divide whole numbers, finding quotients with and without remainders; and
- d) solve single-step and multistep addition, subtraction, and multiplication problems with whole numbers.

4.5 The student will

- a) determine common multiples and factors, including least common multiple and greatest common factor;

Grade 5

5.3 The student will

- a) identify and describe the characteristics of prime and composite numbers;

5.4 The student will

create and solve single-step and multistep practical problems involving addition, subtraction, multiplication, and division with and without remainders of whole numbers.

Grade 6

6.6 The student will

- a) multiply and divide fractions and mixed numbers; and
- b) estimate solutions and then solve single-step and multistep practical problems involving addition, subtraction, multiplication, and division of fractions.

Grade 7

7.4 The student will

solve single-step and multistep practical problems, using proportional reasoning.

7.16 The student will

apply the following properties of operations with real numbers:

a) the commutative and associative properties for addition and multiplication;

Grade 8

8.3 The student will

a) solve practical problems involving rational numbers, percents, ratios, and proportions;

Activity One

Supports CCSSM Standards: 4.OA.A.1,2,3; 5.NF.B.5; 6.RP.A.E

Motivation for Student

The goal of this activity is to be able to estimate how many bars are in a box more quickly, so that we can place more customer orders before the timer runs out.

Instructional Sequence

After completing a round of Candy Depot, students will go to their shift log, showing the customer order, the amount they shipped, and whether it was correct or incorrect. The teacher rolls a six-sided die or uses some other method to choose a number between one and six. This value will be the number of boxes that will be shipped. The goal for the student is to figure out how many extra or few bars would be shipped, using the packaging choices they chose, for each of the orders they placed on the shift log.

Example Scenario:

The number 3 is chosen. Bobby looks at his Shift log and sees that for the first order he shipped, which was for 30 bars, he packed 2 bars to a bundle and 5 bundles to a box. Therefore shipping 3 boxes would mean shipping $3 * (5 * 2) = 30$ bars. This is exactly right. If Bobby had gotten this wrong on his shift log, he could now see what he might have done to get it correct. Suzy looks at her Shift log and sees that for the first order she shipped, which was for 24 bars, she packed 3 bars to a bundle and 3 bundles to a box. Therefore shipping 3 boxes would mean shipping $(3 * 3 * 3) = 27$ bars. This is one bundle too many (and also three bars too many). If Suzy had gotten this answer correct on the shift log (e.g., shipping 2 boxes and 2 bundles) she could have seen right away that 3 boxes was too much and know right away that there would be 1 bundle too many.

Modifications/Extensions:

Have students write equations and use properties to accompany the initial steps. For example, Bobby might write:

$$a = \# \text{bars} \qquad b = \# \text{bundles} \qquad c = \# \text{boxes}$$

$$2 * b = a$$

$$5 * c = b$$

$$2 * (5 * c) = a \qquad \text{(uses substitution property)}$$

$$10 * c = a \qquad \text{(uses associative property of multiplication)}$$

$$c = 3$$

$$10 * 3 = 30 \qquad \text{(uses substitution property)}$$

Activity Two

Supports CCSSM Standards: 4.OA.B.4., 4.OA.A.3; 6.RP.A.2.; 7.RP.A.1

Motivation for Student

The goal of this activity is to be able to determine whether or not an order can be made with only boxes and bundles.

Instructional Sequence

With the timer off, students choose the number of boxes and bundles and then are asked to figure out what possible orders (of bars) they could fill without any loose bars or open boxes or bundles (i.e., no fractions!)

Example:

Sue has chosen 4 bars to a bundle and 6 bundles to a box. Which of the following orders could she fill without opening any boxes or bundles or having loose bars? Teacher proceeds to call out customer orders (of bars) and having students decide whether they could fill them using only bundles or boxes. The winner of the activity is the first student to be able to (correctly) fill n orders using their current packing choices. Upon a student thinking they can fill n orders, the teacher can lead a class discussion about how and why the student was (in)correct. For example, suppose the teacher called out 100, 19, 24, 30, and 10 (with enough time between each so students could decide whether they could make the order). Suzy could ship 100 bars (e.g., 25 bundles) and 24 bars (e.g., 1 box) but not the others. The class could talk about why no one could ever fill 19

because it's prime (and too big for that many to be in a bundle), and why Suzy couldn't fill 10 even though $6 + 4 = 10$.

Modifications/Extensions

1. Allow students to modify their bundling/boxing choices before each number is called out. Tally how many "stayed" with the previous choice and how many "changed" to a new packaging arrangement. Tally 9 categories of results: right – right – changed; right –right –unchanged; wrong- right, changed, etc. Have students decide (as a class) whether it is better to change their choices if they couldn't make the first order, using conditional probability.
2. Allow fractions of boxes or bundles. Could either begin or only then restrict to certain fractions, such as unit fractions. If any fraction is allowed, students should eventually realize that they could always fill any order.

Activity Three

Supports CCSSM Standards: 5.NF.B.5b, 6; 6.RP.A.3; 7.NS.A.3

Motivation for Student

The goal of this activity is to be able to build up bundling and boxing strategies that you will need for level two of Candy Depot.

Instructional Sequence

With the timer off on level two, students are asked to write down at least two and as many as five bundling/boxing possibilities that they could use to satisfy the first order. Before shipping, they are asked which (if any) of their choices would work to satisfy the upcoming order(s), and how.

Example:

Suppose the first order is for 24 bars, the second order is for 6 bundles, and the third order is for $\frac{2}{3}$ of a box.

The student might write

- a) 2 bars per bundle, 6 bundles per box (2 boxes)
- b) 3 bars per bundle, 4 bundles per box (2 boxes)
- c) 3 bars per bundle, 8 bundles per box (1 box)
- d) 3 bars per bundle, 2 bundles per box (4 boxes)

Then

- a) 1 box
- b) 1 box and 2 bundles
- c) 6 bundles
- d) 3 boxes

Then

- a) 4 bundles
- b) 2 bundles and 2 bars
- c) 5 bundles and 1 bar
- d) 1 bundle and 1 bar

Modifications/Extensions

1. Write using ratio symbols instead of words.
2. Instead of looking at the subsequent order, students are asked to determine which unit fractional orders of a box they can satisfy with their choices of bundles and boxes used to satisfy the first order. They should list out fractions such as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, ... $\frac{1}{12}$ and determine whether they could fulfill such a fractional order of a box with (at least) their first choice.

***CandyDepot* Prompts and Reflection Questions**

The following are prompts and reflection questions that teachers can pose to students playing *CandyDepot*. Some of these questions are best posed for individual students during game play, when they encounter particular problems. Other questions might be posed to the whole class immediately after playing the game, so that they can reflect on what they learned. These prompts and questions are organized by level—the level in which they might be most pertinent.

Level 1:

- (1) After a student has chosen the number of bundles per box, ask the student how many bars will be in a box.
- (2) When a student receives an order for a fraction of a box (e.g., “ $16/3$ boxes”), ask the student what a unit fraction ($1/3$) of the box would be.
- (3) In the shift log, ask the student to list out as many possible ways they could have made each order correctly (but not necessarily efficiently).
- (4) Is it true that there is always one best way to correctly ship a customer order?
- (5) After students have mastered Level 1, challenge them to try every combination of bundling and boxing choices (there are 64 possible choices!) to practice working with different factors.

Level 2:

- (1) Suppose you received an order of $7/4$ of a box. Could you ship that order if you had packaged two bars per bundle and 2 bundles per box? If so, how? If not, why not?
- (2) Suppose you received an order of $3/5$ of a box. Could you ship that order if you had packaged 5 bars per bundle and 2 bundles per box? If so, how would you ship it? What if you had packaged 2 bars per bundle and 5 bundles per box instead?
- (3) With the timer off, have students list out as many possible ways that they could choose bars and boxes to make all of the three orders on the screen without modifying the bars or boxes.

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