Teacher Guide (2018)

ELM Teacher Guide

An Introduction to ELM

Emerging Literacy in Mathematics (ELM) is an online bilingual tool created to help early elementary students develop their number sense. Students develop these skills when they are encouraged to select and use appropriate mathematical techniques to solve problems. ELM aims to reduce math anxiety by increasing children's confidence in their mathematical abilities. This encourages more children consider careers in math, science, and engineering.

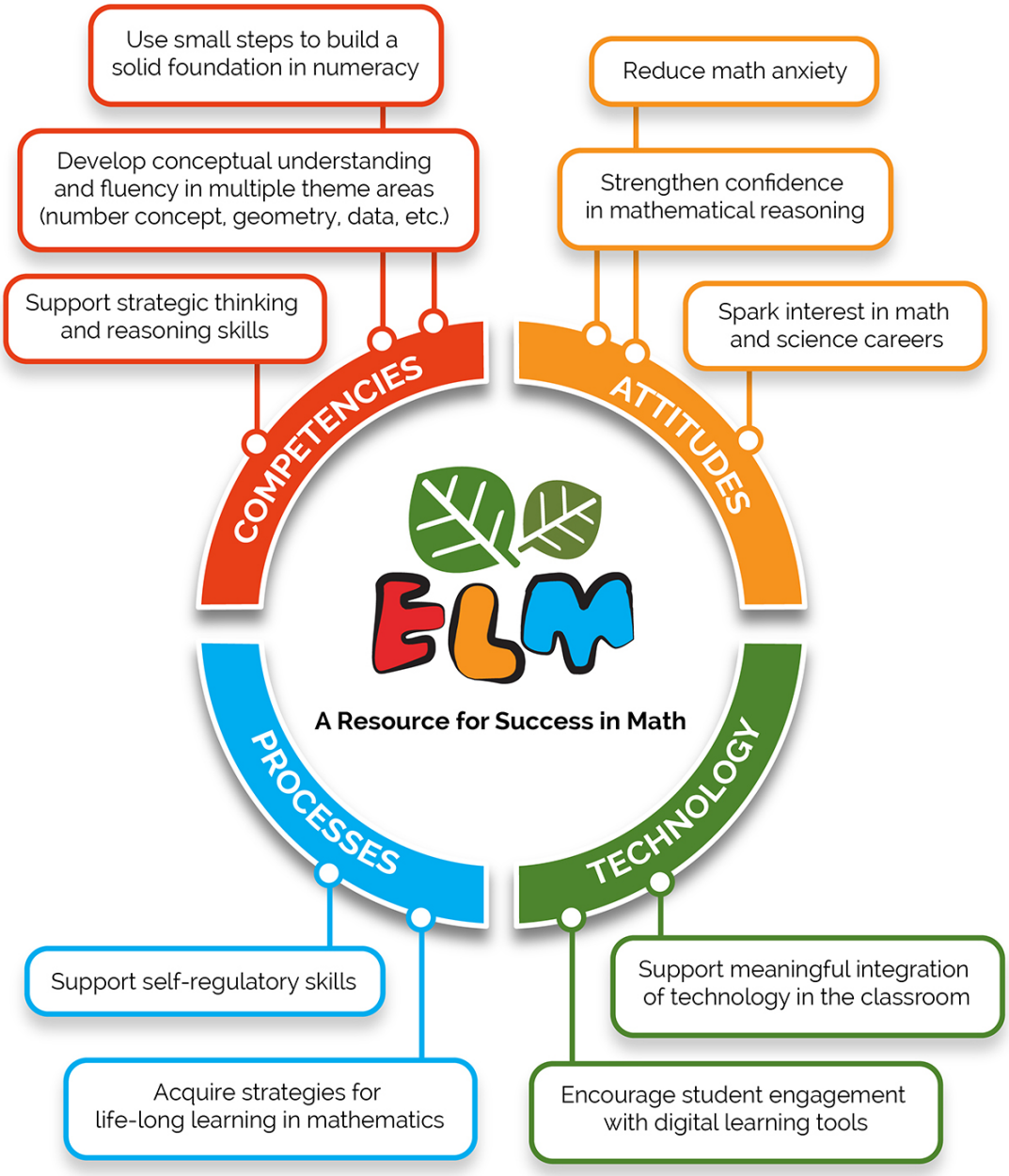
ELM concentrates on five themes: **Number Concept, Geometry, Patterns, Data,** and **Number Line.** These themes cover core mathematical ideas: count, compare, add, subtract, decompose, place value, identify shapes, translate patterns, bar graphs/tables, and number as displacement.

ELM steps build slowly and carefully; students start with steps that use concrete physical actions and progress towards steps that employ symbolic representations. Each step provides sufficient repetitions for children to achieve both fluency and understanding. In addition, students are able to work at their own pace without penalties. The steps provide instant access to situational audio help and visual feedback is provided to confirm success or assists in understanding error(s).

Teachers can access a number of lesson plans that support the use of ELM in the classroom. As well, a number of offline lessons were also developed to deepen understanding of core ideas and introduce an additional theme.

ELM was made possible with funding from *Ministère de l'Économie, de l'Innovation et des Exportations* (MDEIE) and the Max Bell Foundation.

A Framework for Success



Evidence-based Practice

As ELM was being developed, it was field-tested in a number of Quebec schools within the **English Montreal School Board (EMSB), Commission scolaire de la Pointe-de-l'Île (CSPI), Commission scolaire de la Beauce-Etchemin (CSBE)** and **Eastern Shores School Board (ESSB)**. With every iteration of the tool we sought confirmation that the activities met their intended objectives, supported student mathematic achievement, and explored students' motivation towards learning mathematics. The results obtained in these first rounds of pilot testing were promising. When comparing standardized test scores, ELM students were consistently higher than those of their peers in the control group. Likewise, ELM students' mathematical emotions scores reported significantly lower anxiety towards learning mathematics than the control students.

The 2016-2017 study was designed as a two group, pre-post test, with 26 classes from the above-mentioned school boards participating (14 experimental and 12 control) with a total of 338 grade 1 students. In addition, 12 teachers from British Columbia have been using ELM to teach mathematics to their grade 1 classes. We are currently processing the pre-test data collected in the fall of 2016 and are looking forward to analyzing the results once the post-testing is completed in May 2017.

In addition to the above, we have begun piloting ELM internationally to confirm the global relevance of the software. We have been working with teachers in various primary schools in Mombasa, Kenya. The preliminary data collected from 162, K-1 students suggest significant improvements in mathematic skills measured on the standardized test (GMADE, Group Mathematics Assessment and Diagnostic Evaluation). In particular, the gains are important in the Concepts and Communication subtest that address the language, vocabulary and representations of mathematics and the Process and Applications subtest measuring the students' ability to take the language and the concepts of mathematics and apply the appropriate operations and computation to solve a word problem. In order to succeed on this subtest, the students need to apply appropriate strategies when solving the problems and to reason and estimate an answer that makes sense. It is important to note that students in K (N=73) and grade-one (N=89) classes improved their mathematic skills equally well.

We would like to thank all of the participating schools for their participation in these studies and for helping to make ELM the best that it can be.

This Guide

This guide is designed to provide information on the ELM software to help teachers that are interested in using the software with their students. It provides an overview of the structure of the tool and detailed descriptions of the online steps. This guide also provides an overview of the Teacher Module. This includes an explanation of the teacher management features and details on how to access additional resources.

Languages

ELM is fully bilingual. Students and teacher can toggle between English and French by clicking on the language icon on the LTK+ lobby page.

Figure 1: Language Toggle

A French version of this Teacher Guide is available on the French *Teacher Resource* page.

Teacher Tip: If you do not see the ELM tool in the LTK lobby then the system administrator has turned off ELM. Please contact them to access the tool and all of its features.

ELM's Home Page: Main Features

Themes and Ideas

ELM is organized in terms of *Themes* (overarching branch of mathematics), which are further divided into different *Ideas* (mathematical concepts). Each Idea has a certain number of *Steps* to slowly build a student's understanding of the concept and guide students in gaining proficiency. Any of the Ideas are accessible at any time, but the student needs to progress through the steps sequentially the first time they access the Idea. Once they complete all steps within an idea, they can access any step for further practice.

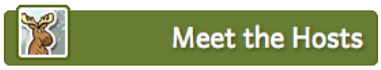
Teacher Tip: The student does not need to complete an Idea before starting another one. For example, after a student has worked through the initial three steps in Count, the student could be asked to do the first step in Compare, Add and/or Subtract.

Meet the Hosts

Each mathematical *Theme* covered in ELM is associated with an animal host. Some themes cover multiple mathematical *Ideas*.

Host		Theme	Ideas
	Chuck	Number Concept	• Count • Compare • Add • Subtract • Decompose • Place Value
	Tia	Geometry	• Identify shapes
	Ivan	Patterns	• Translate Patterns
	Kiros	Data	• Bar Graphs/Tables
	Matilda	Number Line	• Number of Steps (Offline) • Comparison of Position (Offline) • Number as Displacement
	Paco	Mathematical Language	• Introduction to the Bus (Offline)
	Ruby	Extra	

The students can learn more about the hosts by visiting the *Meet the Hosts* page



. Each host will introduce themselves as well as state what skills the students will learn and practice through the Ideas presented within their specific theme.

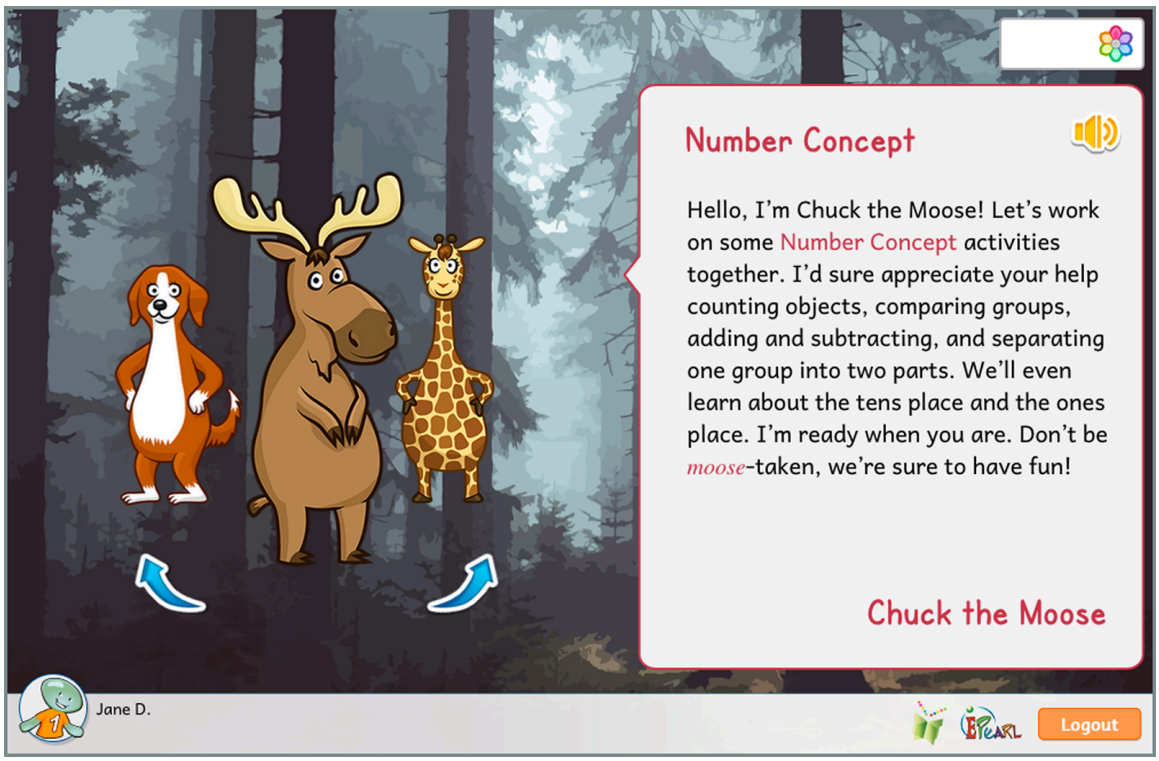


Figure 2: Meet the Host page – Chuck's Introduction

Accessing Ideas

The wheel on the homepage allows students to cycle through all of the Ideas in ELM. Alternatively, they can use the 'See All' button 

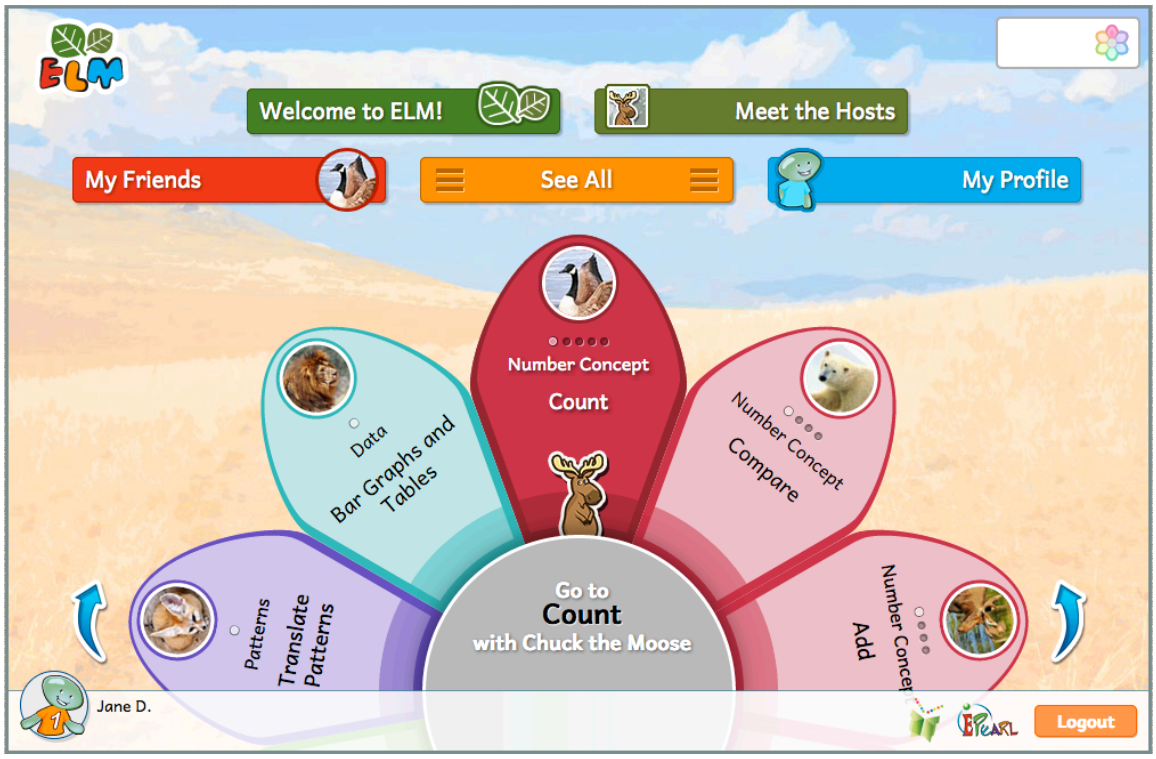


Figure 3: ELM's homepage

Progress

Students may select any Idea from the homepage. However, the steps within an Idea must be completed sequentially. Therefore, student accounts will restrict access to steps until the prior step has been successfully completed.

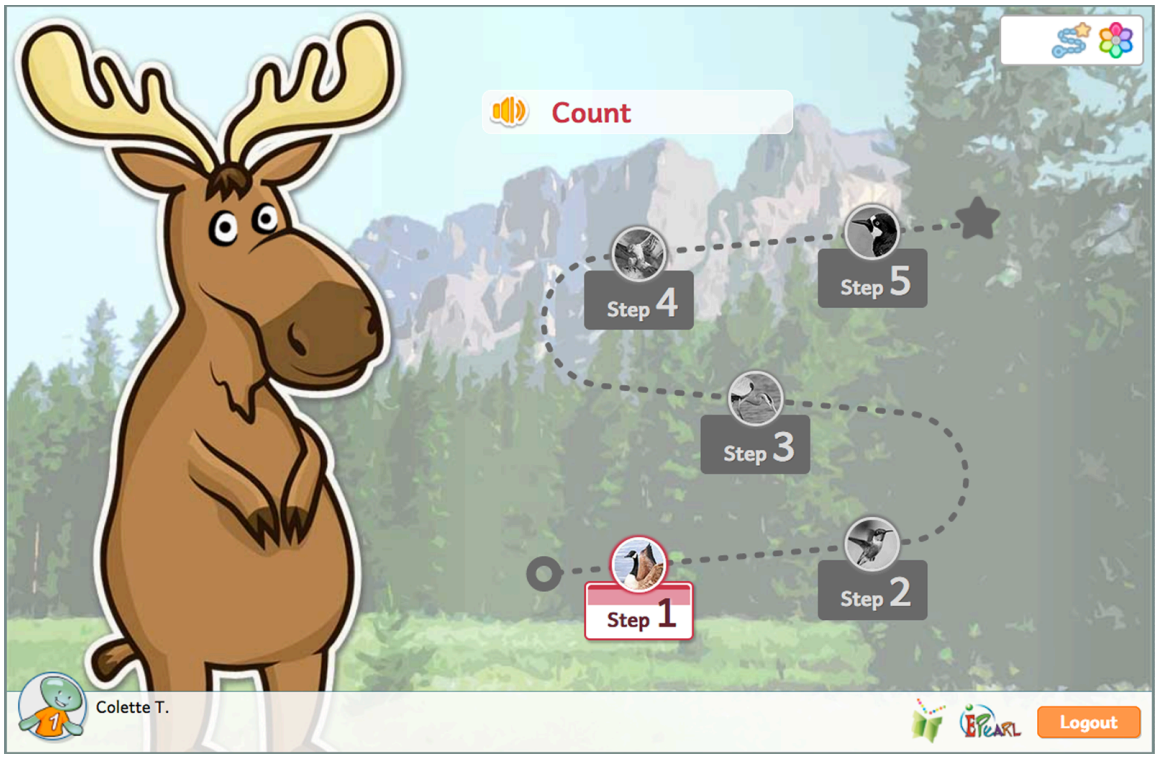


Figure 4: Student Account Progress - Step Restrictions

The homepage provides a quick summary of a student's progress. The steps within an Idea are represented by a button. There are four types of buttons

Icon	Meaning
White circle	Can access the step
Grey circle	Cannot yet access the step
Red circle	Requires help with the step
Gold star	Completed the step

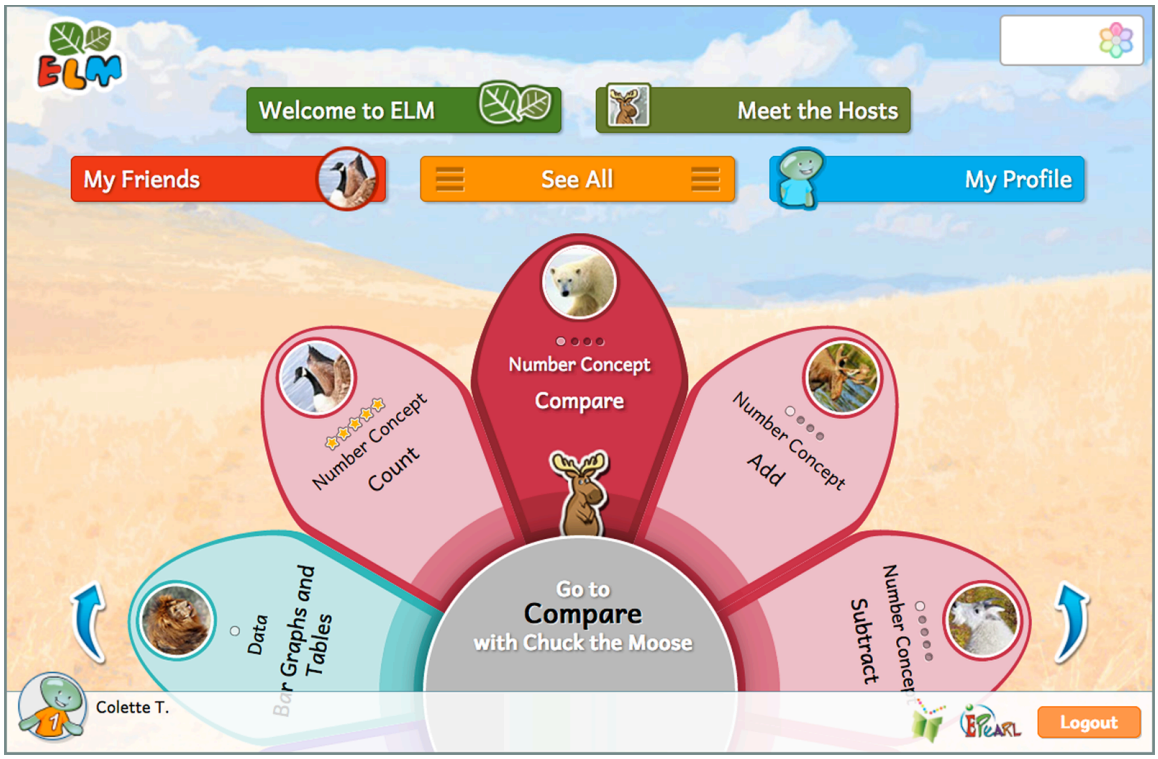


Figure 5: Homepage - All of Count's steps are completed, while only Compare's step 1 is accessible

Soft-lock

The soft-lock feature is intended to identify and aid the students that struggle with the activities.

If students make three consecutive errors in one set (represented by one puzzle piece), the activity will be reset. The host will pop up to let them know what happened. They can attempt to complete the activity with a new situation but at the same level they had been before they were reset. The teacher is not yet notified of the student's difficulty with the activity.

Figure 6: After three errors, the activity is reset

If the student makes another three consecutive errors, the soft-lock will trigger. This means that the activity will be reset again but this time the teacher will be notified in a number of ways. For starters, as the teacher circulates in the classroom, he/she can look for this icon  , which appears on the bottom-left corner of the screen. Even though a soft-lock has been triggered, the student is not prevented from continuing the activity on his or her own. This ensures that the student is not hindered if the teacher is unable to address all concerns as they happen. However, it is important for teachers to know where students experienced difficulty. Whenever a soft-lock is triggered, the teacher receives a notification in their account's *Teacher Manage* section.

Figure 7: Soft-lock is triggered

Validation

ELM was designed to go beyond a simple confirmation of whether the student's answer is correct or incorrect. Whenever the student submits an incorrect answer, the software will compare their answer to what's on screen and/or indicate how the student might correct the error. This is presented in a visual manner. For complex situations, there is additional audio to guide the student in understanding the error. The intention to is promote self-correction.

Differentiation

In each classroom, the teacher faces students with a range of background knowledge, abilities and learning styles. In an effort to provide an environment that perpetuates positive attitudes to mathematics and also accommodates this diversity within a classroom, ELM includes several features:

1. In every step, the  allows a student who is unsure about how to proceed to seek context sensitive help, which may be delivered visually, aurally or in both manners;

2. Whenever a student clicks on 

to indicate that they have completed a task, if the student has made an error, then the software suggests the nature of the error visually and/or aurally;

3. If a student repeatedly has difficulty completing a task in the software, the software will send an alert to the teacher, and also display a small icon on the student's screen,  , so that if the teacher is moving about amongst the students, the teacher can spot that a student has been having difficulty and intervene;

4. In the *Teacher Manage* section, the teacher can adjust the number of repetitions that each student or group of students must perform so as to complete a step. See under Teacher Module for more information on *Teacher Manage*.

Other Navigation Options

At any time within a step, the top navigation menu can be used:

There are also navigation icons on the bottom-right corner of the screen:

 Go to the LTK+ lobby page

 Navigates to the ePEARL tool

Signs the user out of their LTK account

My Animal Friends

Each of ELM's steps is associated with an animal friend. When the student starts the step, they are presented with an incomplete puzzle of an animal. The missing puzzle piece represents how many times they must successfully complete a set in the step. The teacher is able to adjust the assigned repetitions. The student gains the friend by completing the puzzle.

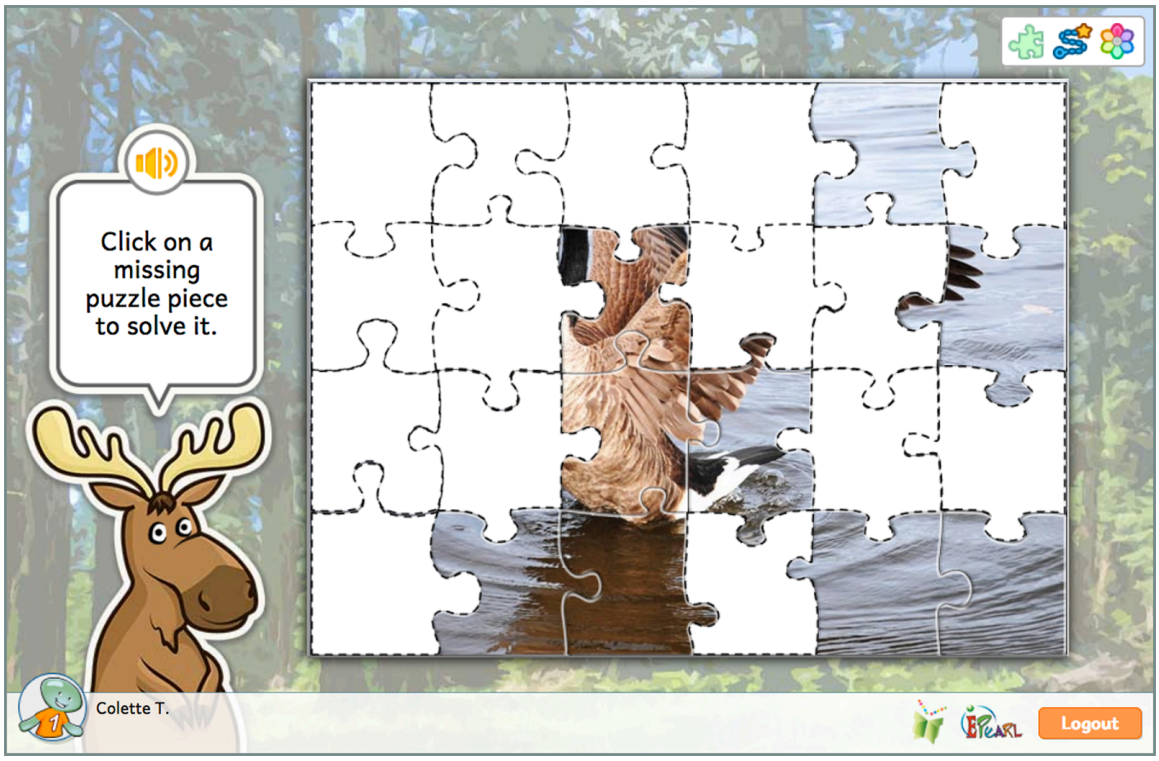


Figure 8: The student must complete the puzzle to gain the animal friend

Animal friends can be accessed by going to the "My Friends" page 

. Only the animal friends that were gained will be visible on this page. If students gained the friend, they will have a badge of the animal and they will be able to access the associated trading card(s). These cards contain the animal's name, some information about the animal, and the puzzle pictures the student completed. Students may click on the speaker to have this information read aloud.

There are two trading cards per animal friend. If the student repeats the step (either because it has been assigned in their plan or because they went back to practice on their own), they will have a second trading card for that animal friend.

Teacher accounts will have all badges/trading cards visible even if the steps have not been complete.

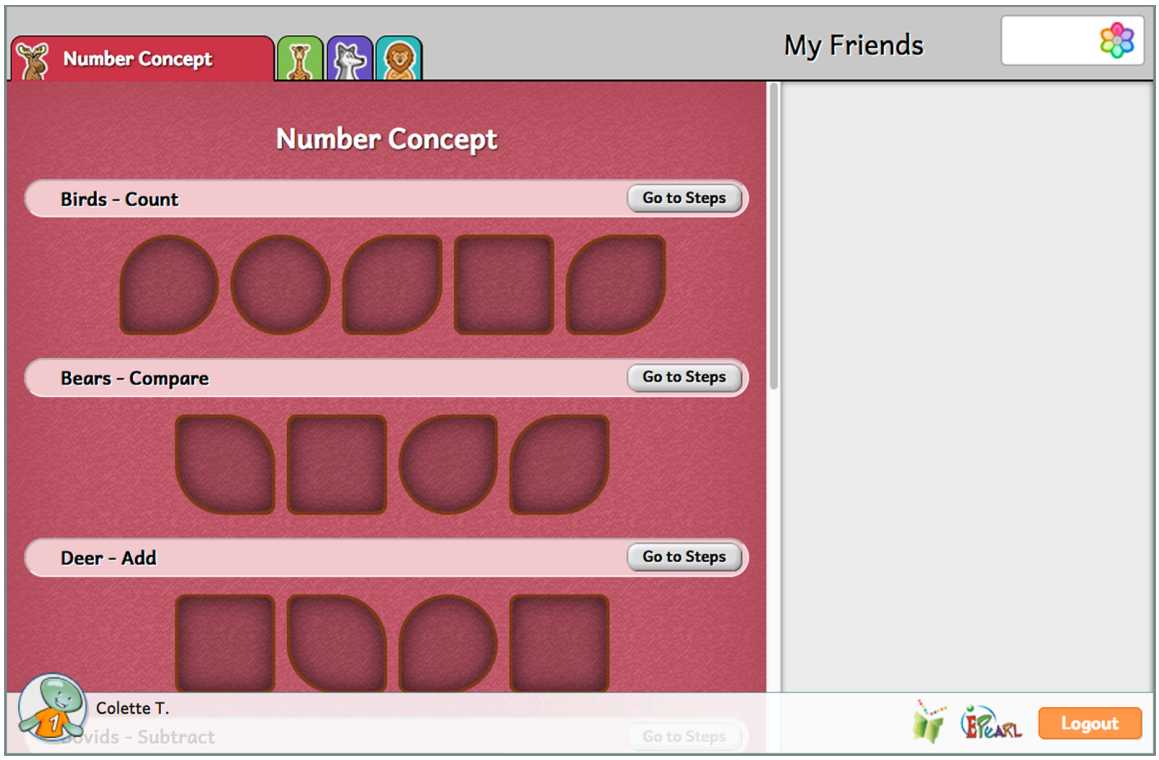


Figure 9: The 'My Friends' page - The student has not gained any friends yet

Figure 10: The 'My Friends' page with badges and trading cards

Each idea is associated with a particular animal family. For example, all of the animal friends gained in the Count steps are birds.

Teacher Tip: The trading cards contain a short blurb about the animal. These can be used as an introduction to animal science or a way to practice reading skills and comprehension. Each card has an audio button that reads out the text. The student can read with the software or compare their attempt to the audio.

My Profile

Clicking on the *My Profile* button can change the icon associated with the account 

. To change the icon, click on an alternative image and then select the accept button  .

Figure 11: My Profile Page

Online Themes

ELM's steps teach basic mathematical concepts for grade 1 as covered in the Quebec Education Program, as well as the standards for grade 1 set out by the *National Council of Teachers of Mathematics* (NCTM) in the United States and Canada.

ELM features a unique account and profile for students. Each student is tracked as she/he progresses through the steps, to help a teacher understand what concepts their student has mastered and which, if any, she/he has difficulty with and needs assistance to learn.

Number Concept

- Count: 5 steps
- Compare: 4 steps
- Add: 4 steps
- Subtract: 5 steps
- Decompose: 4 steps
- Place Value: 9 steps

Geometry

- Identify Shapes: 3 steps

Patterns

- Translate Patterns: 1 step

Data

- Bar Graphs/Tables: 2 steps

Number Line

- Number as Displacement: 1 step

Number Concept

In this theme, students are encouraged to see 'number' as a set or a collection of objects. ELM's activities are intended to develop students' fluency in recognizing numbers, comparing numbers, adding and subtracting numbers, decomposing numbers into either a sum or difference of two numbers, and understanding the place value of numbers. Students also familiarize themselves with mathematical symbols and vocabulary.

Teacher Tip: Most of the steps in this theme focus on the numbers 1-9. This allows students the opportunity to learn the concept in a way where they can verify the answer for themselves by using their fingers.

Count

It is essential for students to become familiar with the basic numerals (1 through 9) and the quantity each represents. The steps are structured to move from concrete to abstract means of counting a set of objects. These steps provide the opportunity for students to gain fluency at subitizing (the ability to instantly recognize the number of objects in a set of objects presented without any conscious counting).

Teacher Tip: It's a good idea to start ELM with the Count steps. Many of the other ELM ideas call on students' counting strategies.

Step 1

This step focuses on the importance of counting each object in a set just once. Students are asked to click on each bird to count it. This introduction is meant to mimic how students likely count tangible objects. As they click on each bird, the counter on the right automatically fills up. Even though students are not yet asked to interact with the counter, this should reinforce the counting. This models the strategy of using markers to record the count of objects.

Figure 12: Count Step 1

Incorrect Feedback

The student may make an error by not clicking on all of the birds. In this case, the software will highlight the overlooked birds

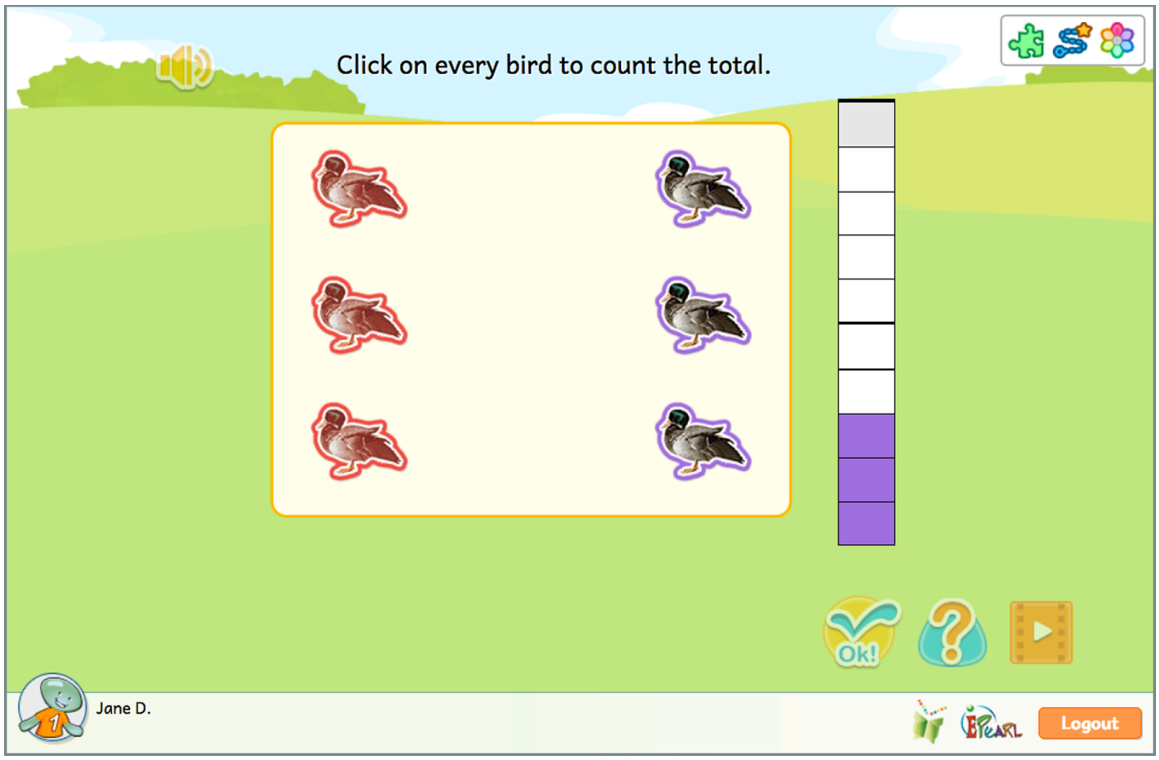


Figure 13: Count, Step 1- Incorrect Feedback Example

Step 2

This step moves to a slightly more abstract version of counting where students are asked record the count directly in a counter. This strategy encourages students to count without physically manipulating the objects in a set. Given the small numbers of objects presented, this step also provides practice for subitizing.

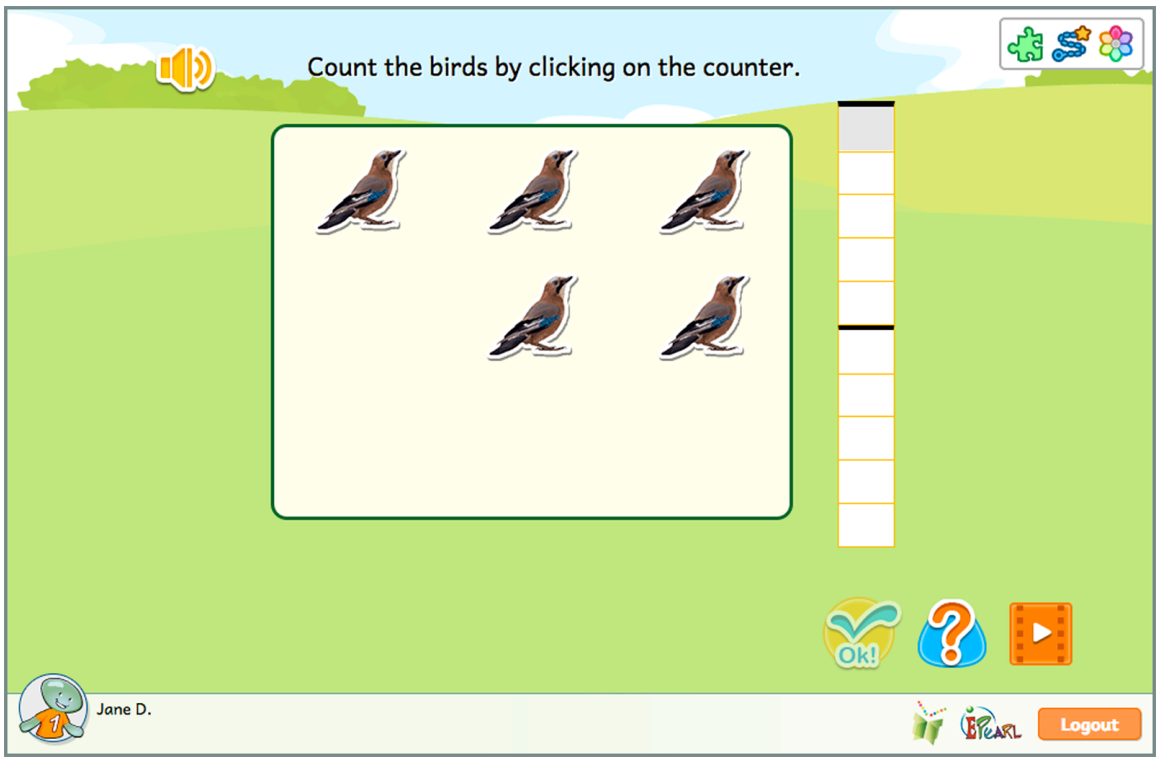


Figure 14: Count Step 2

Incorrect Feedback

There are two ways the student may make an error: counting too few or counting too many. If the student gave an answer that less than the number of birds on screen, then birds equal to the amount that the student enter are highlighted in purple while the rest turn red. If they provided an answer that is more than the number of birds, then the feedback will display additional "ghost" birds on screen.

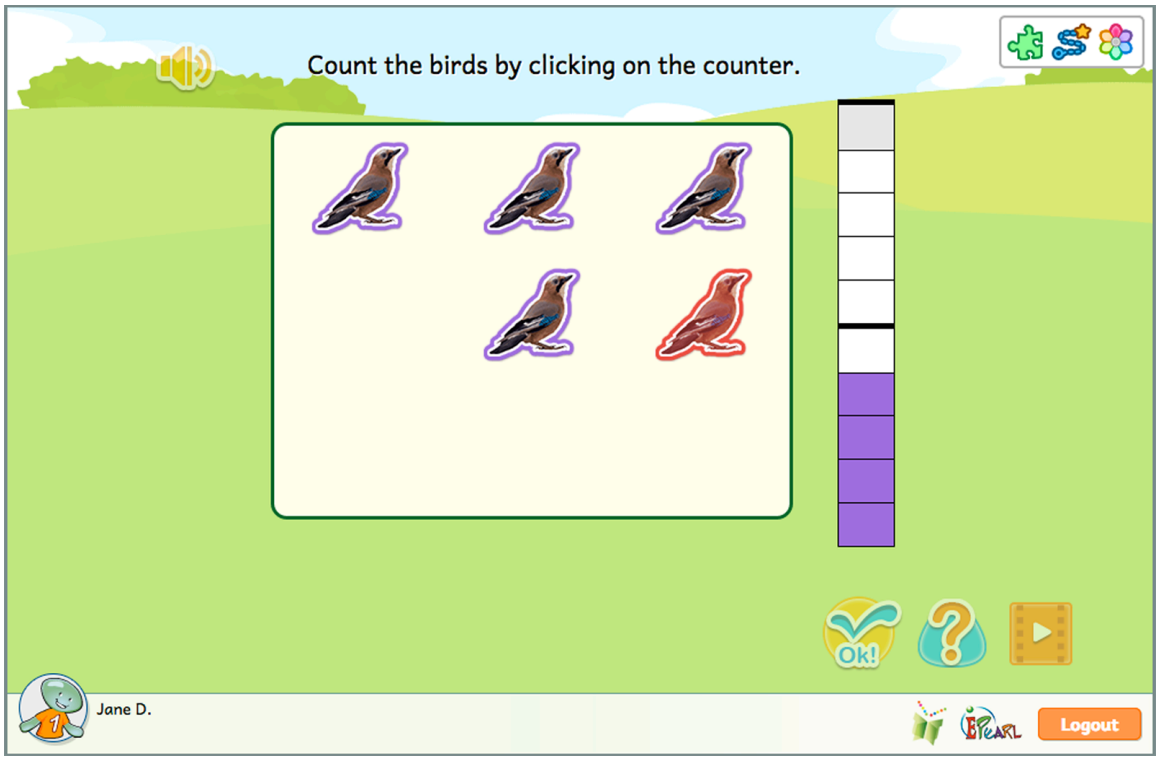


Figure 15: Count Step 2 - Incorrect Feedback Example - Too Few

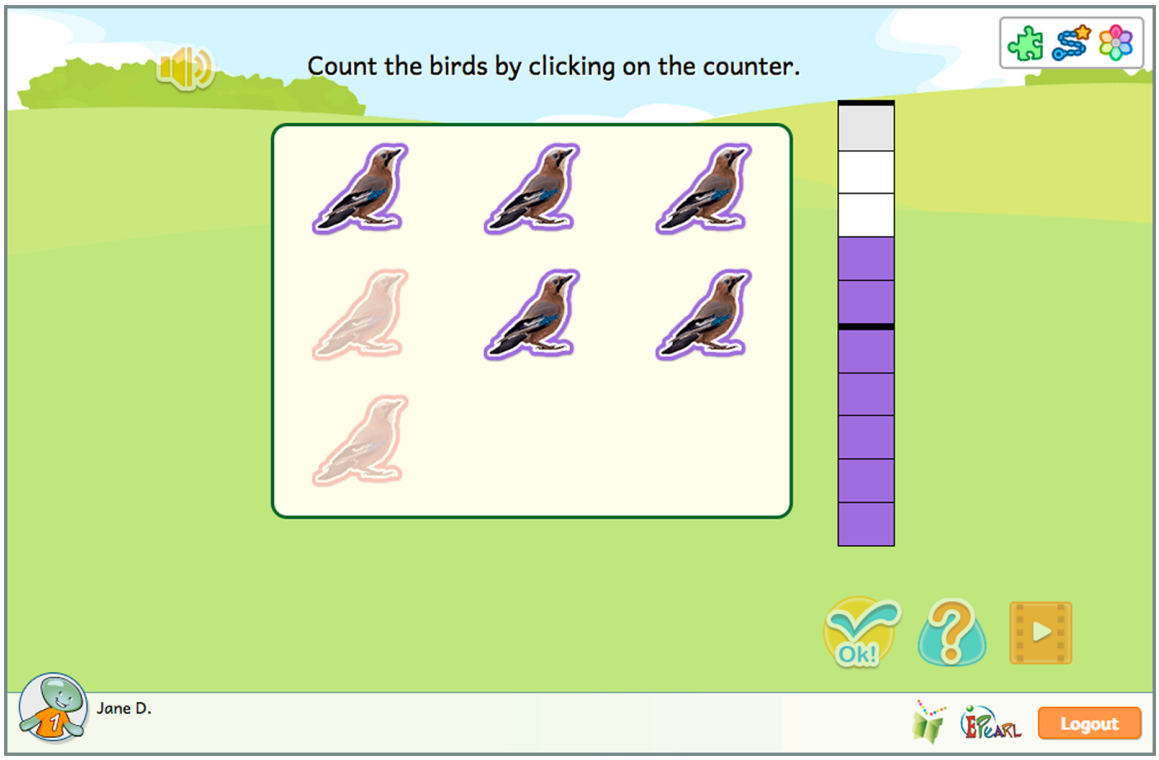


Figure 16: Count Step 2 - Incorrect Feedback Example - Too Many

Step 3

This step builds on the previous one. Students first continue building associations between a mental image of a set of objects and a record on the counter. After successfully doing so, they are asked to select the correct numeral to represent the total count of birds.

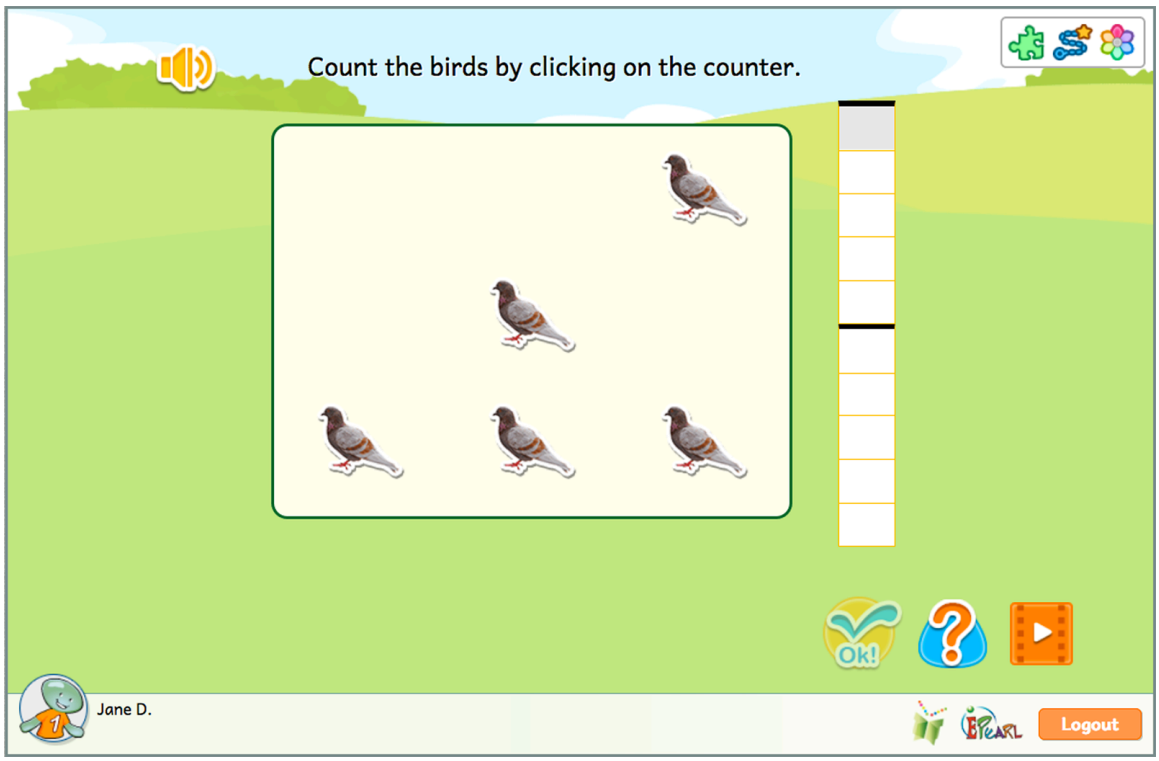


Figure 17: Count Step 3, Phase 2

Incorrect Feedback

In the first phase, there are two ways the student may make an error: counting too few or counting too many. If the student gave an answer that is less than the number of birds on screen, then birds equal to the amount that the student enter are highlighted in purple while the rest turn red. If they provided an answer that is more than the number of birds, then the feedback will display additional "ghost" birds on screen.

In the second phase, the feedback is the same regardless of whether the student answered more or less than the total number of birds. A bracket appears next to the counter to encompass the student's answer. They can then compare their answer to the number of coloured cells in the counter.

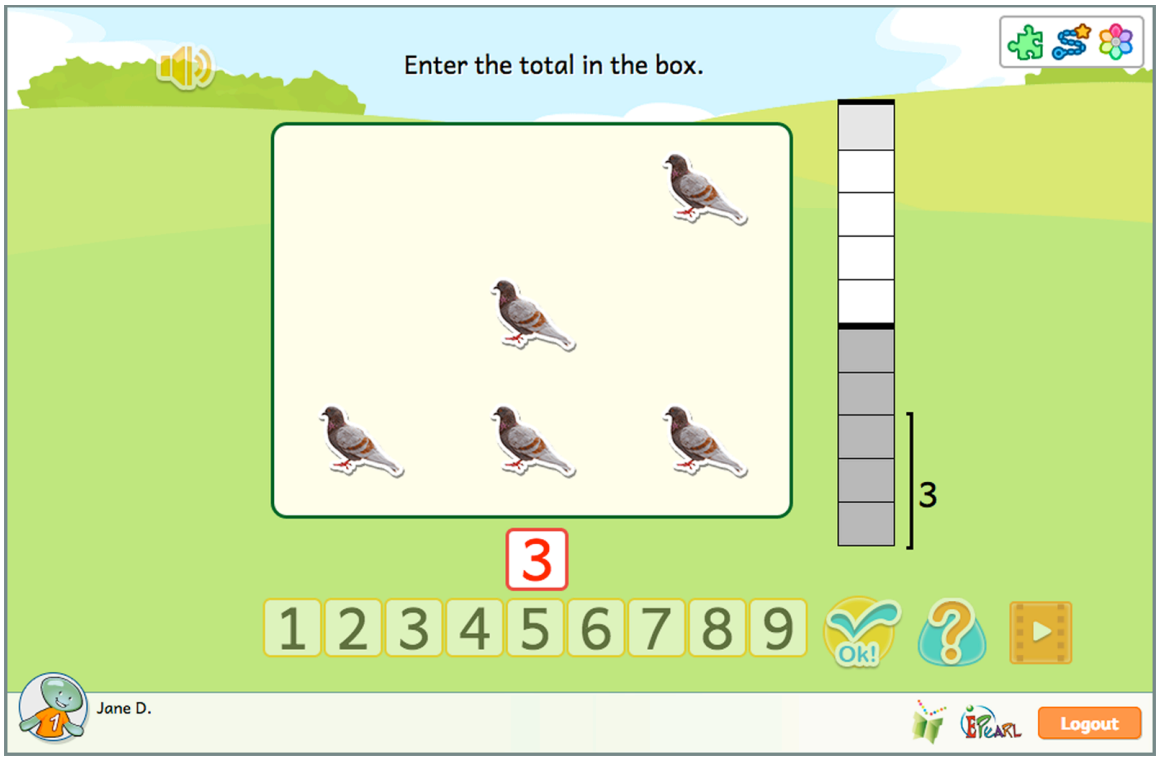


Figure 18: Count Step 3 - Incorrect Feedback Example - Phase 2

Step 4

This step reverses the process by giving students a numeral and having them generate a set of objects to match. The counter automatically adjusts as they add or remove birds to the field.

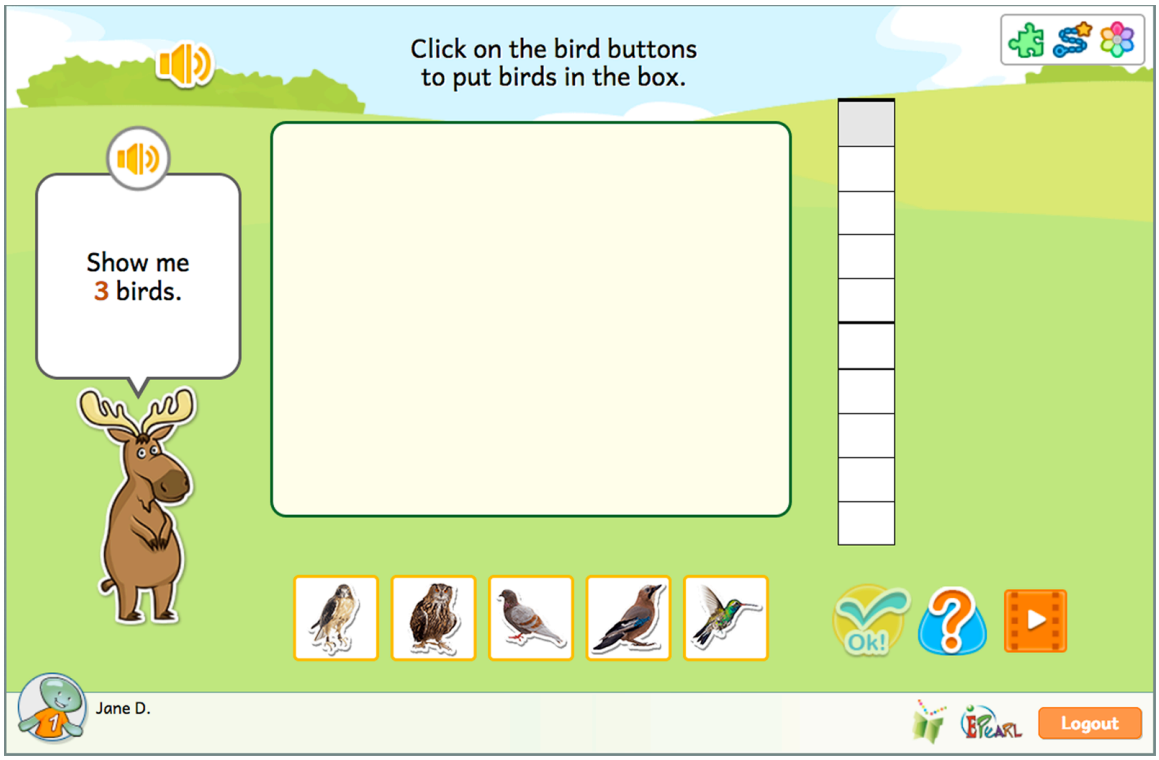


Figure 19: Count Step 4

Incorrect Feedback

The correct numeral will be presented next to the counter to contrast with the student's answer. If the student didn't add enough birds, they will see some cells are still white and thus more birds need to be added. If the student added too many birds, they will see that cells outside of the bracket are filled in.

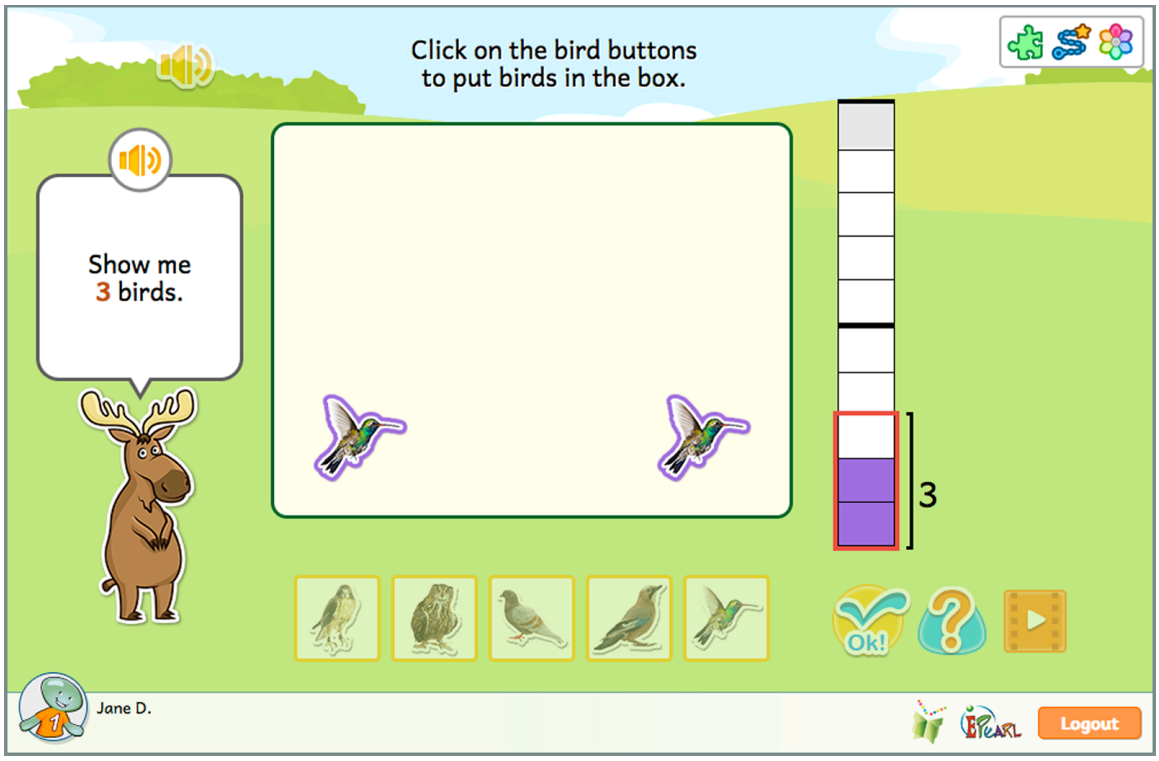


Figure 20: Count Step 4 - Incorrect Feedback Example

Step 5

In this step students are asked to move directly from a given set of objects to the numeral representing that number of objects. This is the most abstract counting activity that calls upon students' subitizing skills.

Figure 21: Count Step 5

Incorrect Feedback

When the student enters a number less than the correct answer, owls equal to student's answer are highlighted. When the student enters a number greater than the correct answer, additional "ghost" birds will appear on screen to visually display what their answer looks like.

Figure 22: Count Step 5 - Incorrect Feedback – Entered a Number Less than the Correct Answer

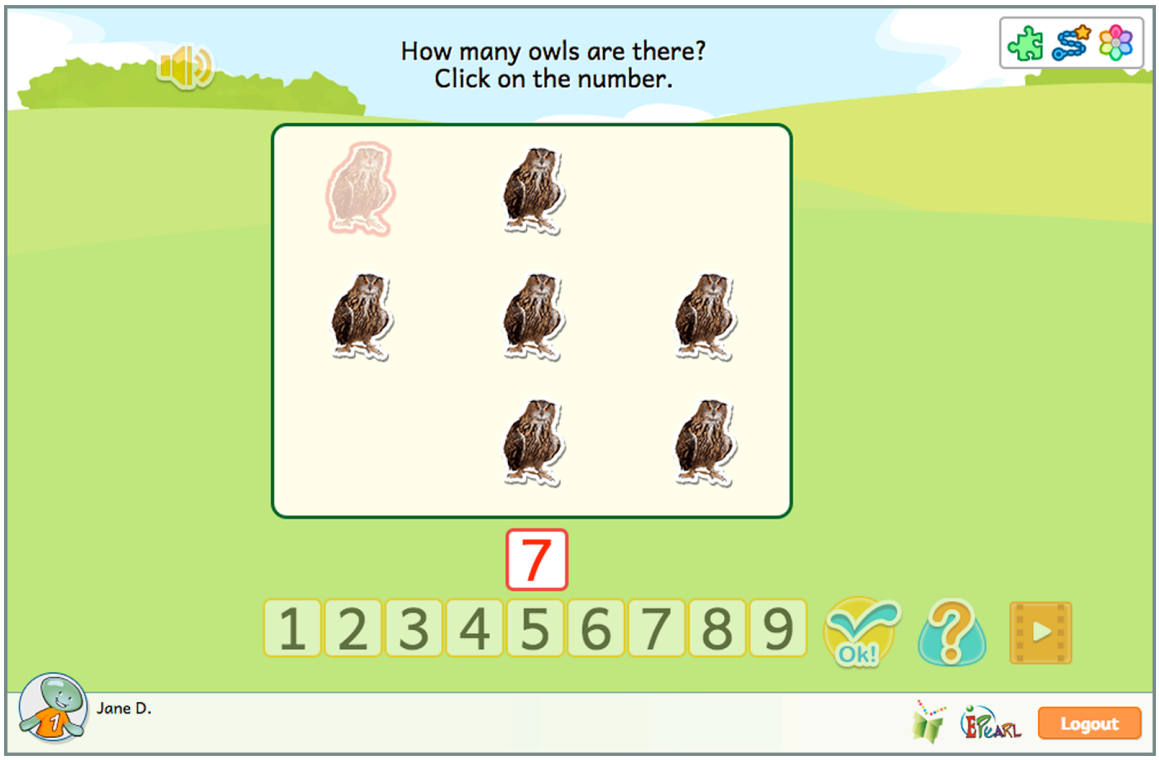


Figure 23: Count Step 5 - Incorrect Feedback - Entered a Number Greater than the Correct Answer

Compare

Students will be asked to count two sets of objects: bears and hockey sticks. They are asked to compare these two sets of objects and determine if they are equal or whether one integer is larger or smaller than the other. These activities expose students to both natural language and mathematical symbols that express and compare the cardinality of two sets.

Step 1

There are a number of bears on screen and students are asked to give each one a hockey stick. Once they add the required number of hockey sticks, students are asked to enter how many there are in each set. Once they correctly state the amount of bears and sticks there are, ELM provides three ways of verbally expressing equality: “is the same as”, “is as many as”, and “is equal to”.

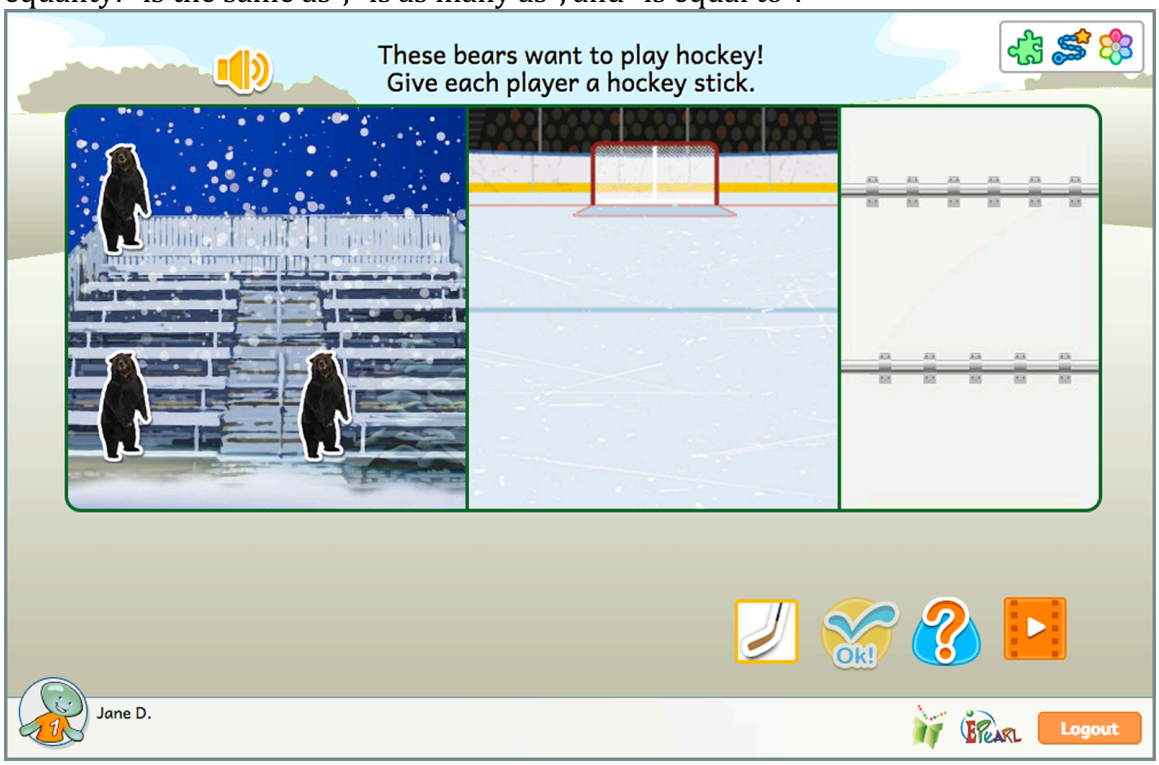


Figure 24: Compare Step 1

Incorrect Feedback

During the first phase, whatever bears and sticks can be matched are moved to the center of the screen. If there are any remaining bears without a stick, they are highlighted in red. If there are additional hockey sticks, they are highlighted in red.

In the second phase, the feedback is displayed sequentially (first on the set of bears, then the set of sticks) so that students can focus their attention on one set of objects at a time. If they enter a number less than the amount of bears and sticks, ELM will highlight the objects not counted in each set. If they enter a number larger than the amount of bears and sticks, additional “ghost” bears and sticks will be displayed.

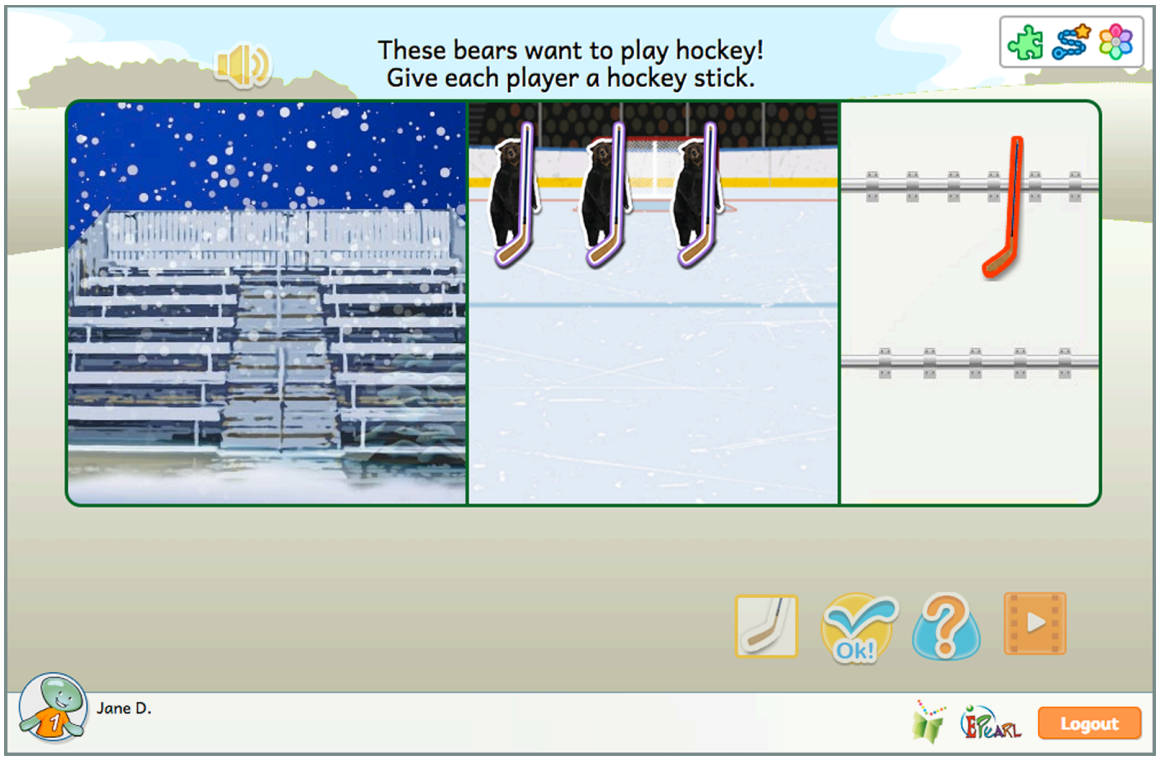


Figure 25: Compare Step 1 - Incorrect Feedback Example in Phase 1

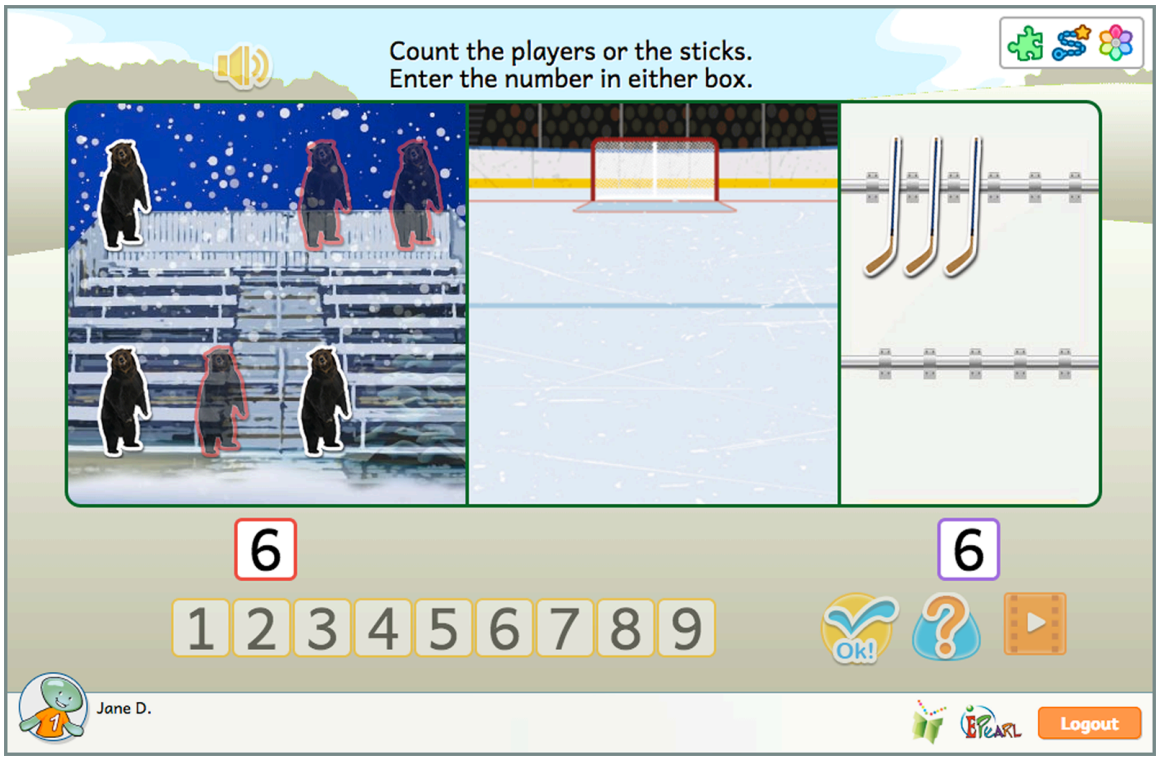


Figure 26: Compare Step 1 - Incorrect Feedback Example in Phase 2 with the Focus on the Bears

Step 2

Building on the previous activity, students are asked to compare the number of bears to the set of sticks, though both sets may no longer be equal. Students are asked to count the number of bears and the number of sticks. Then they match the bears to sticks until all have been matched or the objects in one set have been exhausted. In the final phase, the student must determine which operator fits the situation: = is equal to; > is bigger than, < is smaller than.

Figure 27: Compare Step 2

Incorrect Feedback

During the first phase, if the student entered a number smaller than the correct answer, the number of bears or sticks equal to the answer provided will be highlighted. If the student entered a number higher than the correct answer, additional "ghost" bears or sticks will appear. If the student made an error counting the objects in both sets, the feedback will be provided sequentially.

In the second phase, if students have not matched as many bears to sticks as possible then the remaining bears will be highlighted followed by the remaining sticks. It is important to note that if students attempt to send a bear to the center of the rink when there are no sticks remaining, the bear will be sent back to the left side. This prevents the possibility of having an unmatched bear in the center.

If they make one error in the third phase, it will automatically trigger the reset/soft-lock feature.

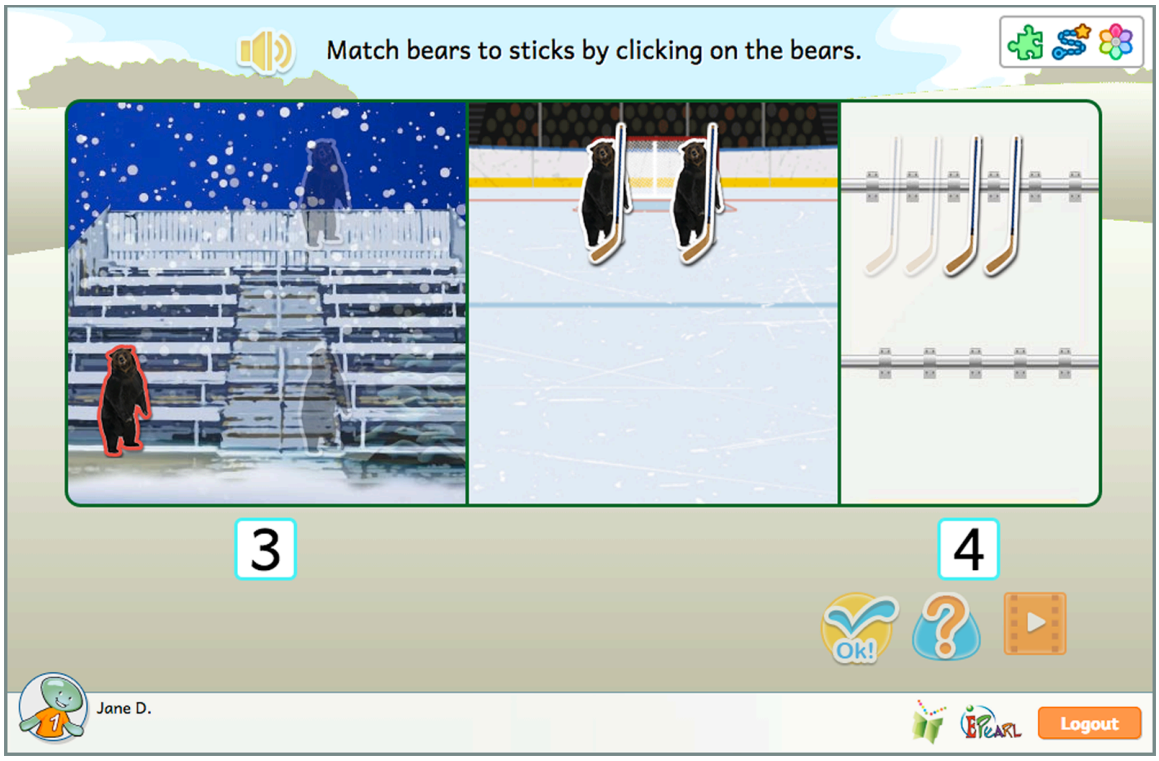


Figure 28: Compare Step 2- Incorrect Feedback Example

Step 3

Much like the previous step, the student must first enter the number of bears and sticks there are in each set. They are once again asked to match the bears to the sticks until all have been matched or the objects in one set have been exhausted. The final phase asks them to select the operator that fits the situation but using on the symbols (< = >). There is no text next to the symbols to reinforce the meaning of the operators, but ELM will automatically read the mathematical statement chosen in order to support student understanding of operators.

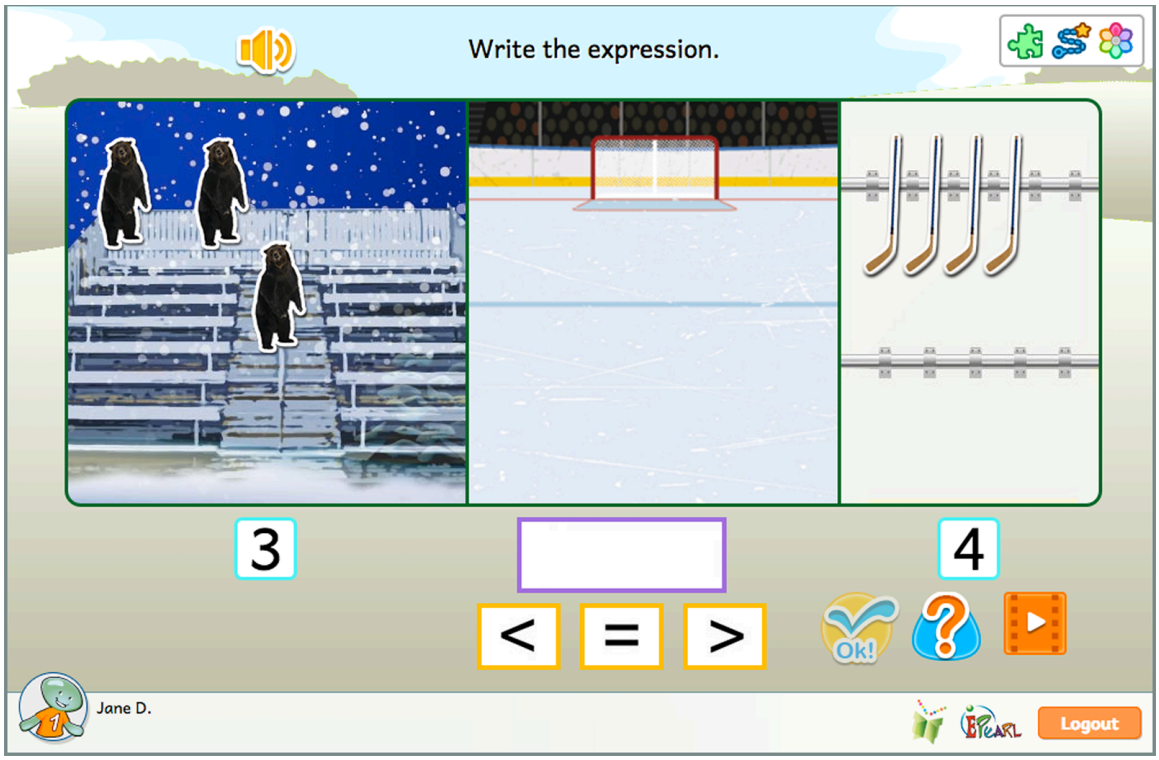


Figure 29: Compare Step 3

Incorrect Feedback

The feedback is the same as the previous step; if the student entered a number smaller than the correct answer, the number of bears or sticks equal to the answer provided will be highlighted. If the student entered a number higher than the correct answer, additional "ghost" bears or sticks will appear. If the student made an error counting the objects in both sets, the feedback will be provided sequentially.

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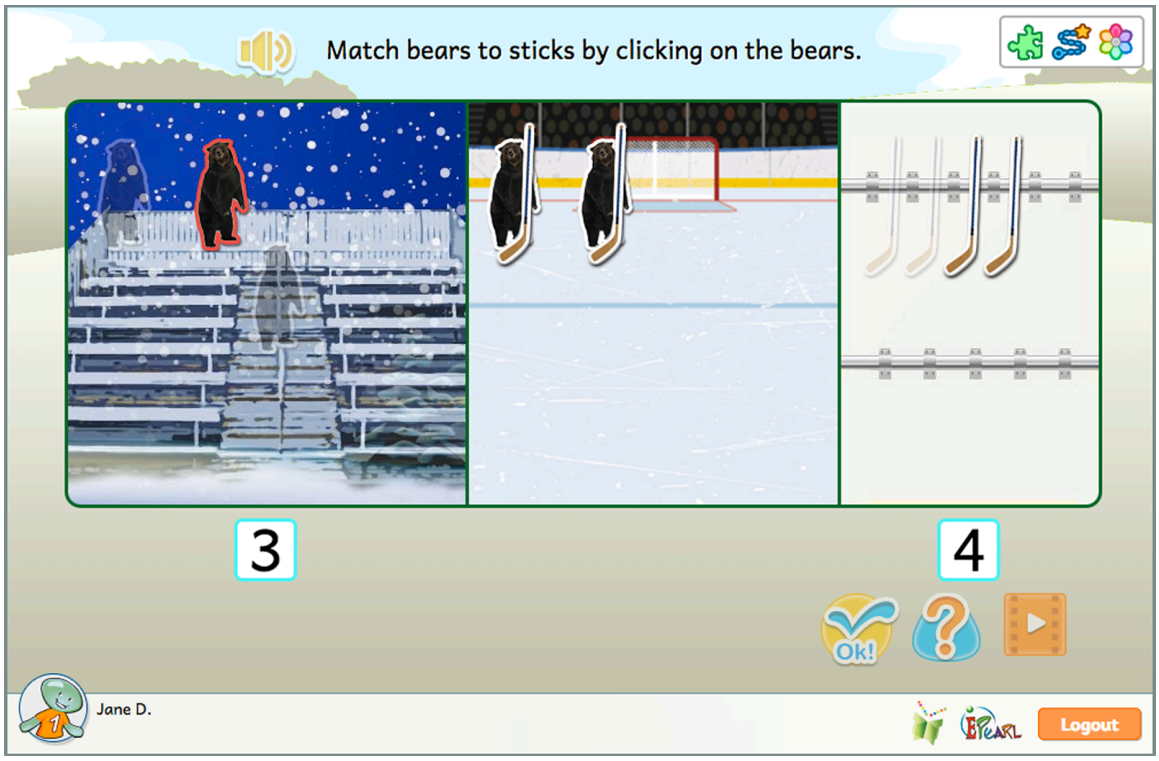


Figure 30: Compare Step 3 - Incorrect Feedback Example

Step 4

In this step, the student is presented with the equation or inequality and he/she has to create two sets to match it. The first asks the student to create the set of bears and the second phase has them creating the set of sticks. The third phase does not require students to manipulate elements on the screen but will match the bears to the sticks to reinforce the validity of the equation or inequality.

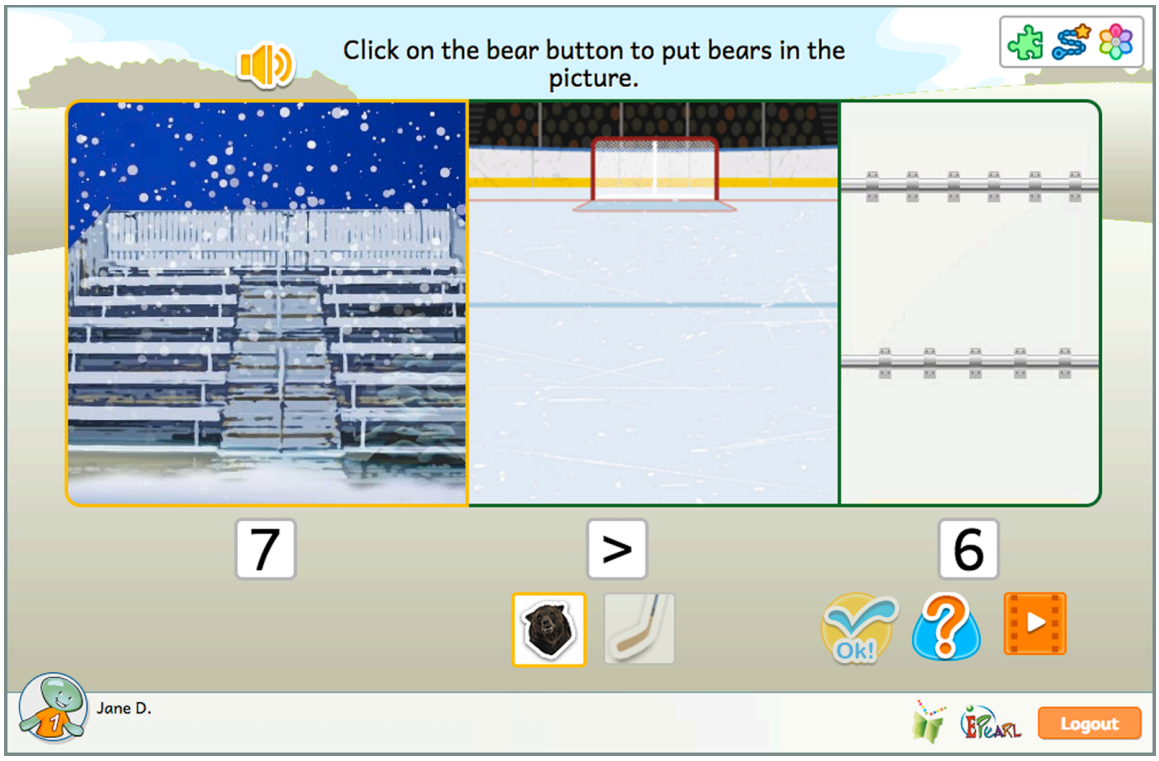


Figure 31: Compare Step 4

Incorrect Feedback

In both the first two phases, if the student added too few bears or sticks, ELM will display additional "ghost" bears and sticks to demonstrate what a correct answer ought to look like. If the student entered too many bears or sticks, ELM will highlight the additional bears and sticks.

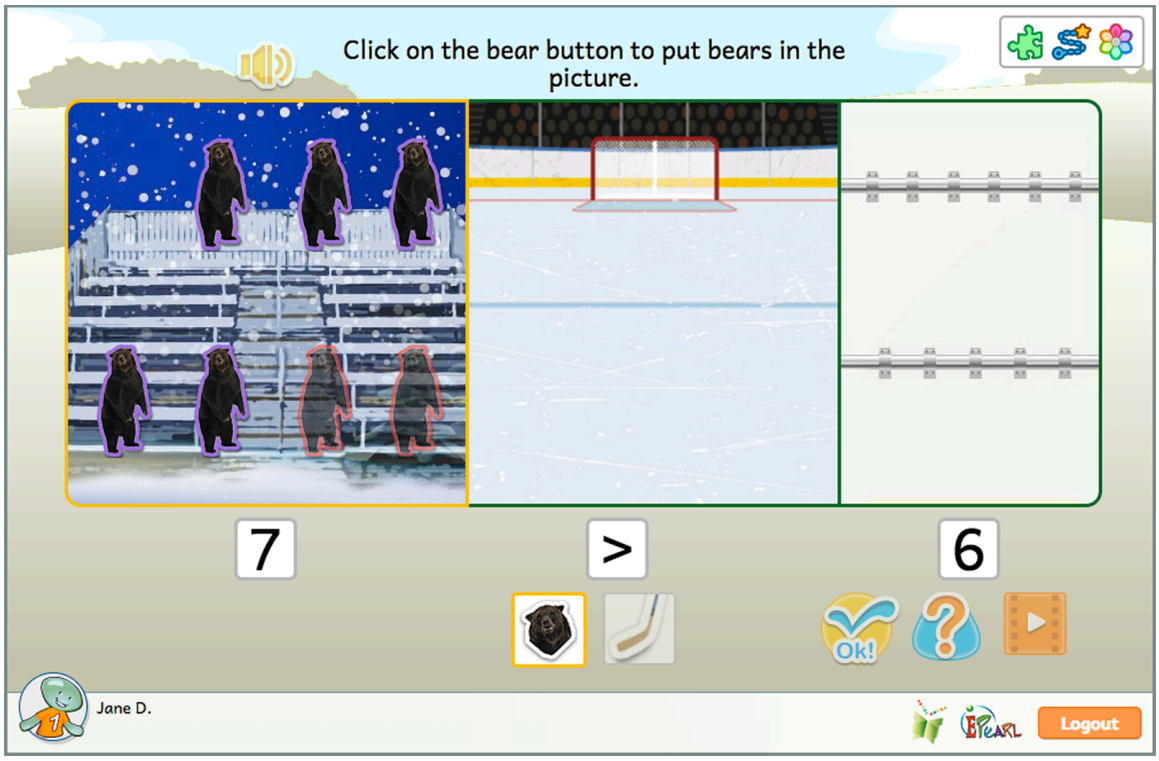


Figure 32: Compare Step 4 - Incorrect Feedback Example for Adding Too Few Bears

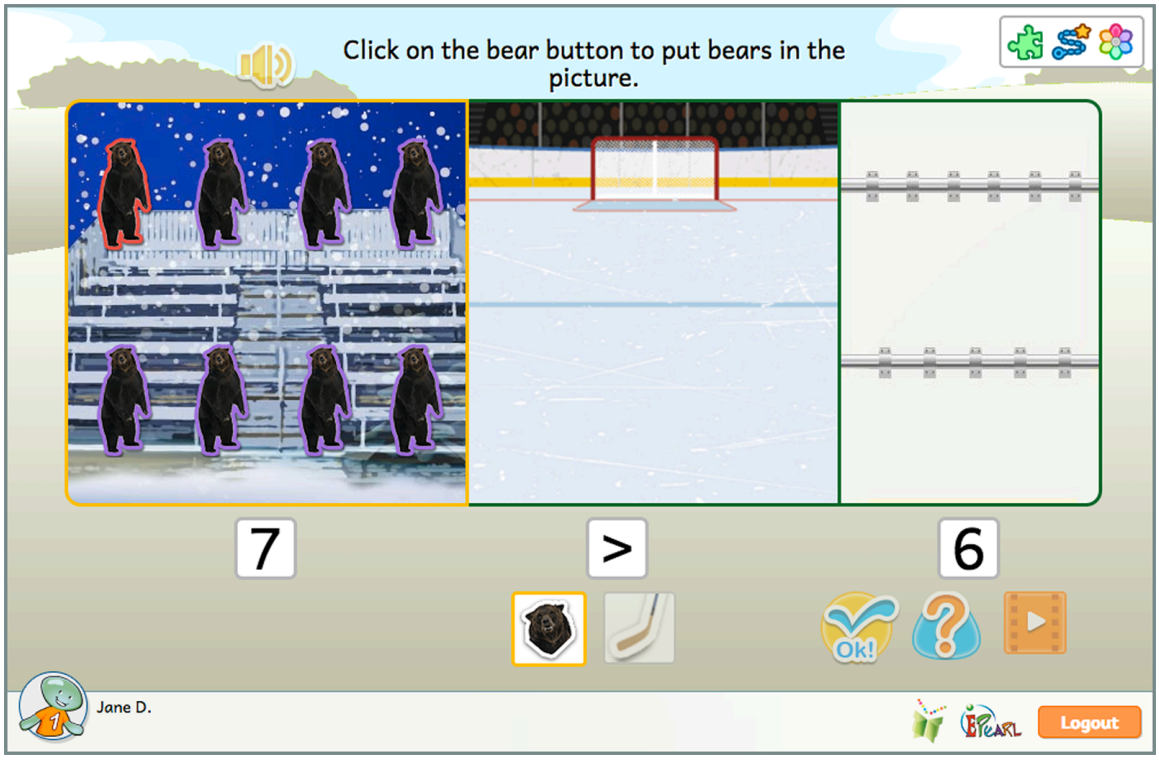


Figure 33: Compare Step 4 - Incorrect Feedback Example of Adding Too Many Bears

Add

This *Idea* asks the student to add the cardinality of two sets animals. They see that the resulting number is the "sum" or "total" and that can be represented by an equation. In the earlier steps, students learn to read the equation. Later, they learn to write these equations by placing the numbers and symbols in the appropriate order.

The steps in *Add* reuse the counting strategies learned in the *Count* steps. This includes clicking on objects to count them and the use of counters to represent cardinality. Each set has its own counter; however, this strategy is extended to use an additional counter to represent the total of both sets. Students are expected to draw their own conclusion as to what each counter is counting and to figure out the logic that ties a counter to a border. This strategy is intended to help students become capable and confident in their understanding in mathematics.

Step 1

The student is introduced to the idea of addition by combining two separate sets into one set. They start by clicking on each animal in the sets. As they do, the animal is counted in the associated counters: one for each set and one for the total. Once all of the animals have been counted, the student is expected to choose the appropriate number symbol to represent the total number of animals in the two sets.

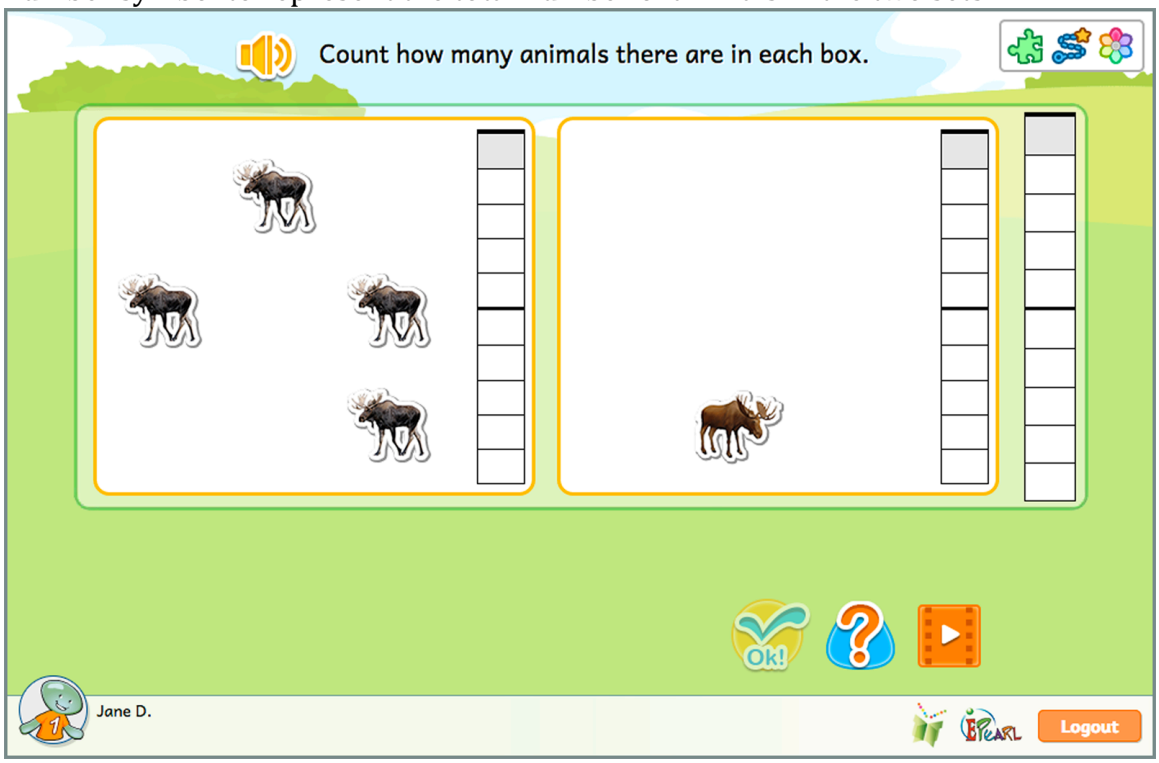


Figure 34: Add Step 1

Incorrect Feedback

In the first phase, if the student made an error by not counting all of the animals, ELM will highlight the animals not clicked on. If errors were made in both sets, the incorrect feedback will show in each set consecutively.

In the second phase, if the student selects an incorrect number symbol for the total, the tool will encircle the counter to match the student's answer. They can then compare their answer to what was counted in the counter in the previous phase.

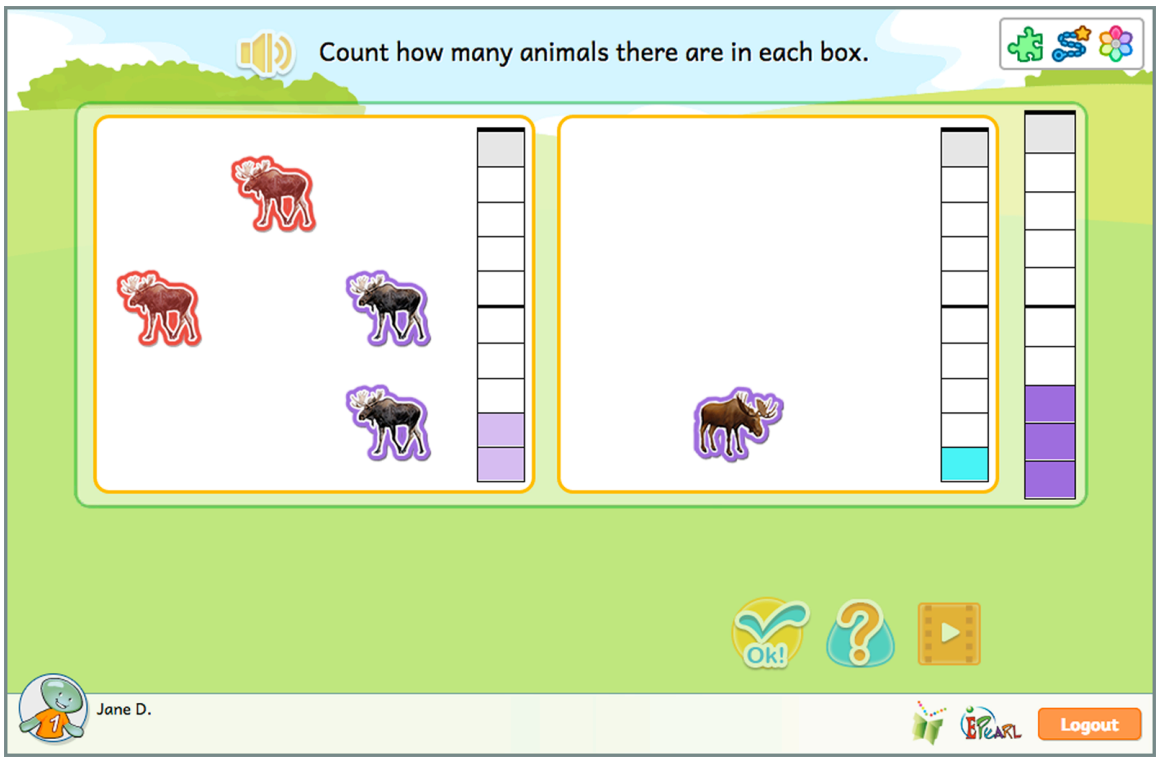


Figure 35: Add Step 1- Incorrect Feedback Example in Phase 1

Figure 36: Add Step 1 - Incorrect Feedback Example in Phase 2

Step 2

This step reinforces the concept of addition as putting two sets of objects together. Students are asked to count the animals in each set by directly entering a numeral in the associated box. If the student's answers are correct, then the rightmost counter's cells fill to match the sum. The student must then select the number symbol that represents the total. If they enter the correct number, ELM will create an equation describing the sum of the animals in the two sets.

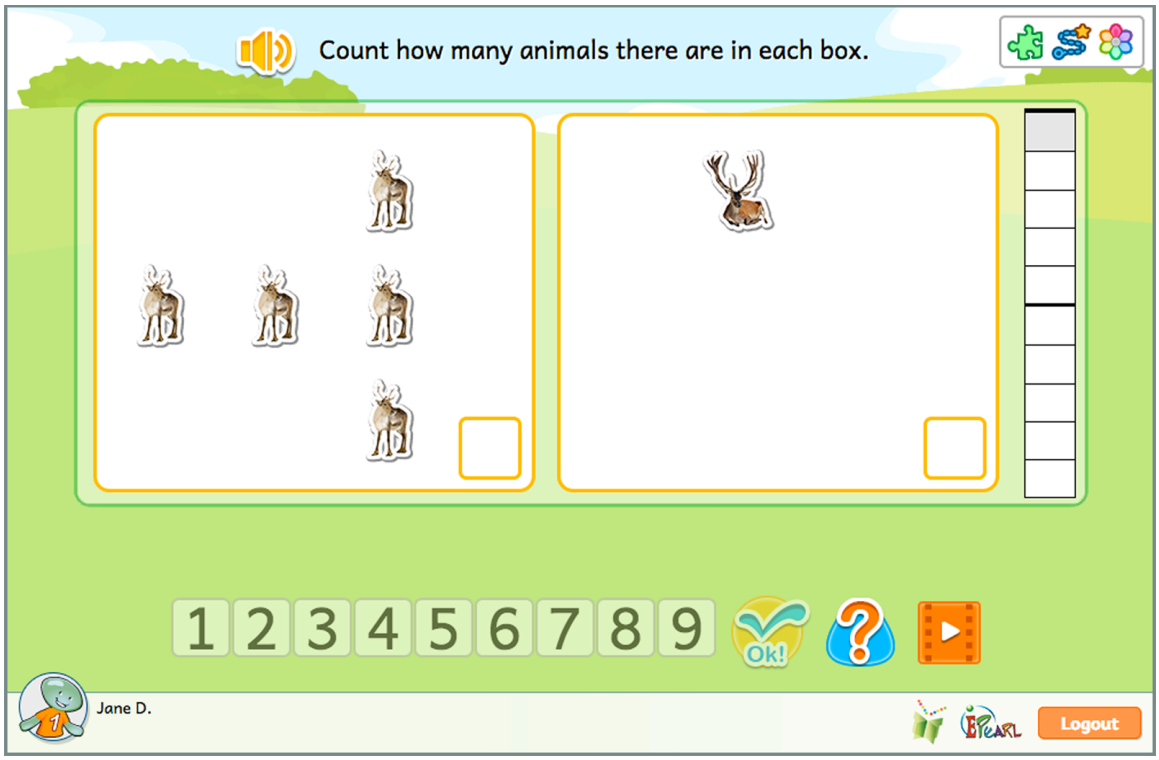


Figure 37: Add Step 2

Incorrect Feedback

If the student makes an error in the first phase, the software will show them what their answer looks like. If they entered a number lower than the animals in the set, then ELM will highlight deer equal to the number entered so that the student can compare this to the total animals in the set. If the entered a number higher than what's in the set, the software will add additional "ghost" deer to show what their answer looks like. If the student makes an error in both sets, the software will show the feedback sequentially.

In the second phase, if the student selects an incorrect number symbol for the total, the tool will encircle the counter to match the student's answer. They can then compare their answer to what was counted in the counter in the previous phase.

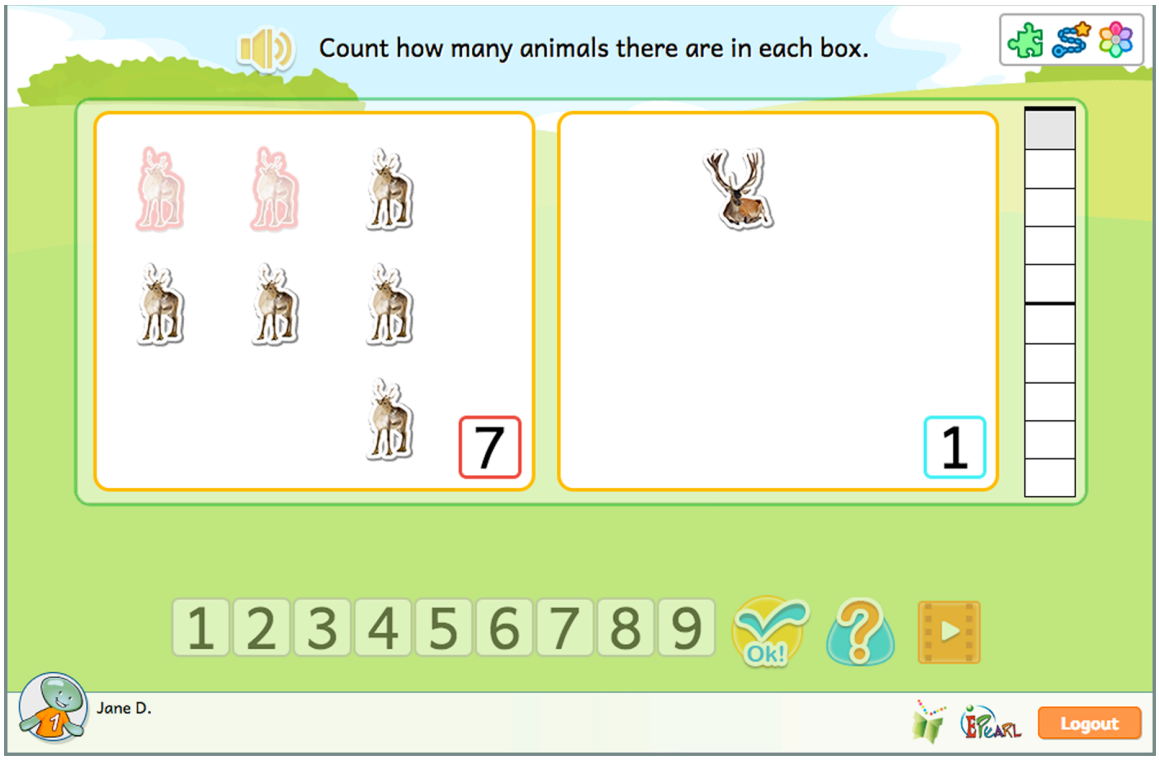


Figure 38: Add Step 2 - Incorrect Feedback Example in Phase 1

Step 3

This step builds on the previous one. The first two phases follow the same structure: students are asked to count the animals in each set by directly entering a numeral in the associated box. If the student's answers are correct, then the rightmost counter's cells fill to match the sum. The student then selects the number symbol that represents the total. However, instead of the software providing the equation, the student is asked to create it by himself or herself.

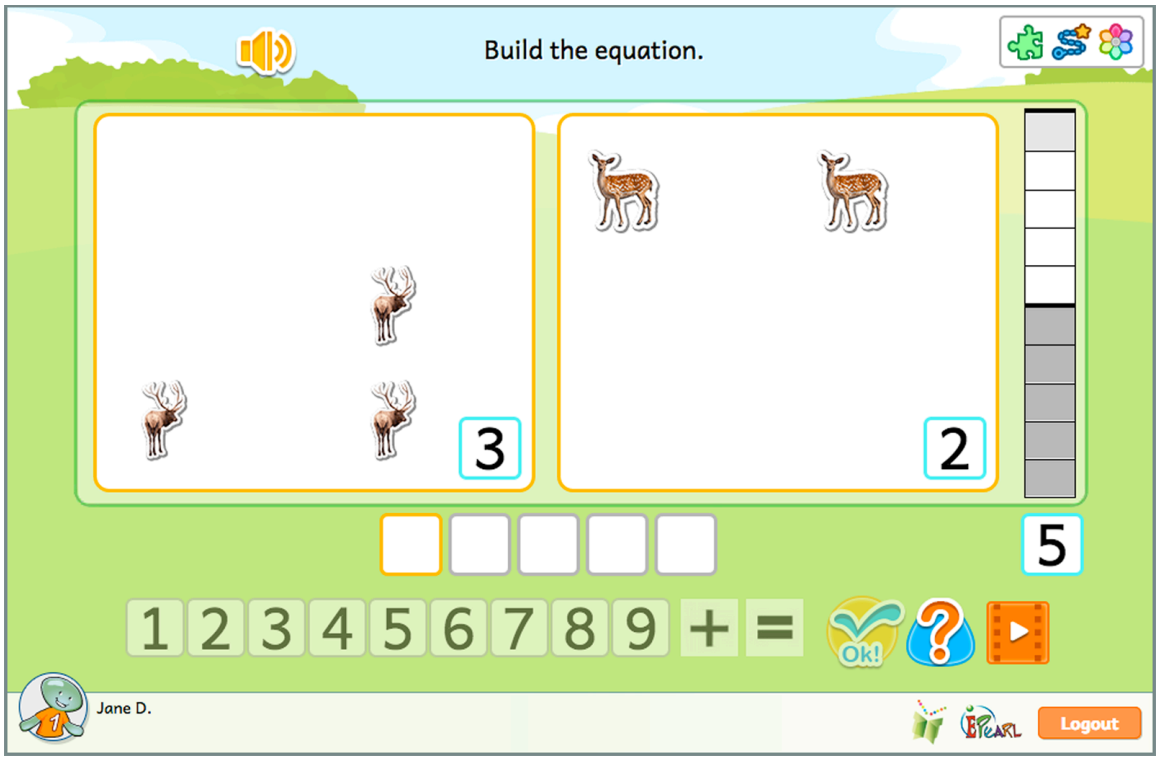


Figure 39: Add Step 3

Incorrect Feedback

The Incorrect Feedback for the first two phases is the same as it was in the previous step. In the first phase, if the student entered a number lower than the animals in the set, then ELM will highlight deer equal to the number entered so that the student can compare this to the total animals in the set. If the entered a number higher than what's in the set, the software will add additional "ghost" deer to show what their answer looks like. If the student makes an error in both sets, the software will show the feedback sequentially.

In the second phase, if the student selects an incorrect number symbol for the total, the tool will encircle the counter to match the student's answer. They can then compare their answer to what was counted in the counter in the previous phase.

In the final phase, if the student did not enter the same numbers in the equation as appears in the boxes above, the first, third and fifth placeholders in the equation will be highlighted. If the student did not use one + and one = sign in their equation, the second and fourth placeholders in the equation will be highlighted. If the largest number in the equation is not in the first or fifth placeholder and adjacent to the equal sign, then the whole equation will be highlighted. In all of these situations, there is additional situational audio to help pinpoint how the student can correct their error.

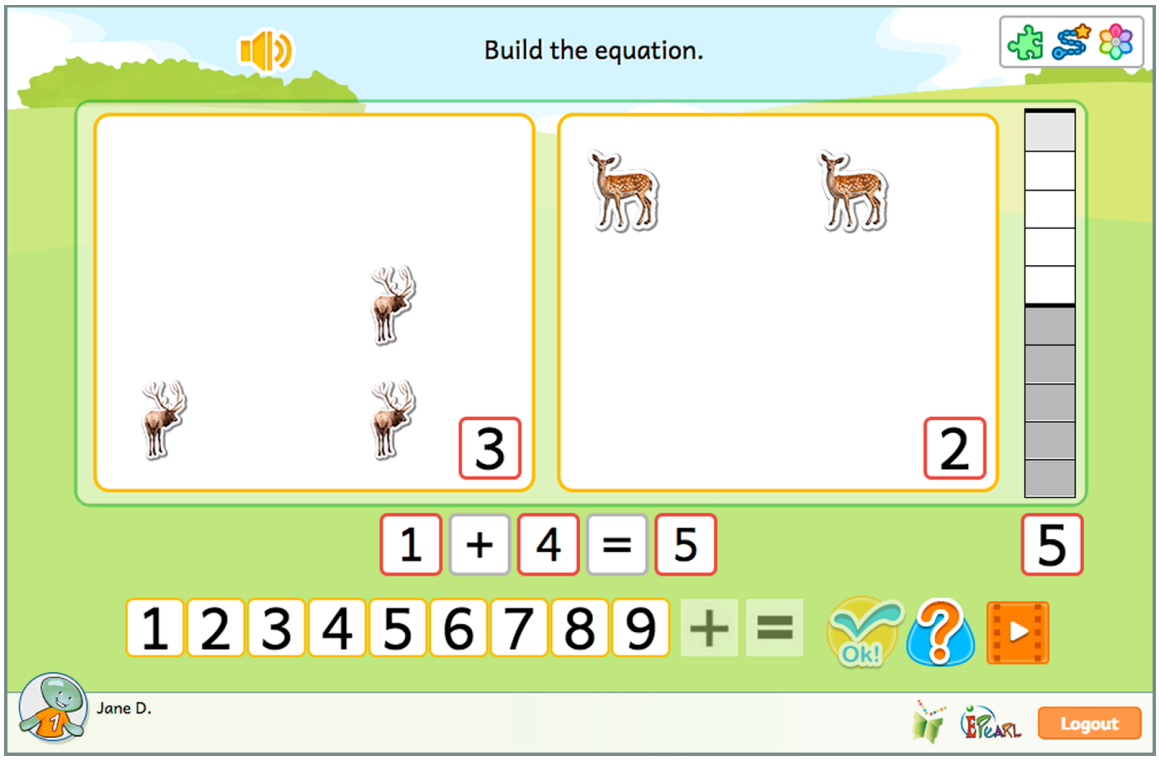


Figure 40: Add Step 3 - Incorrect Feedback Example in Phase 3

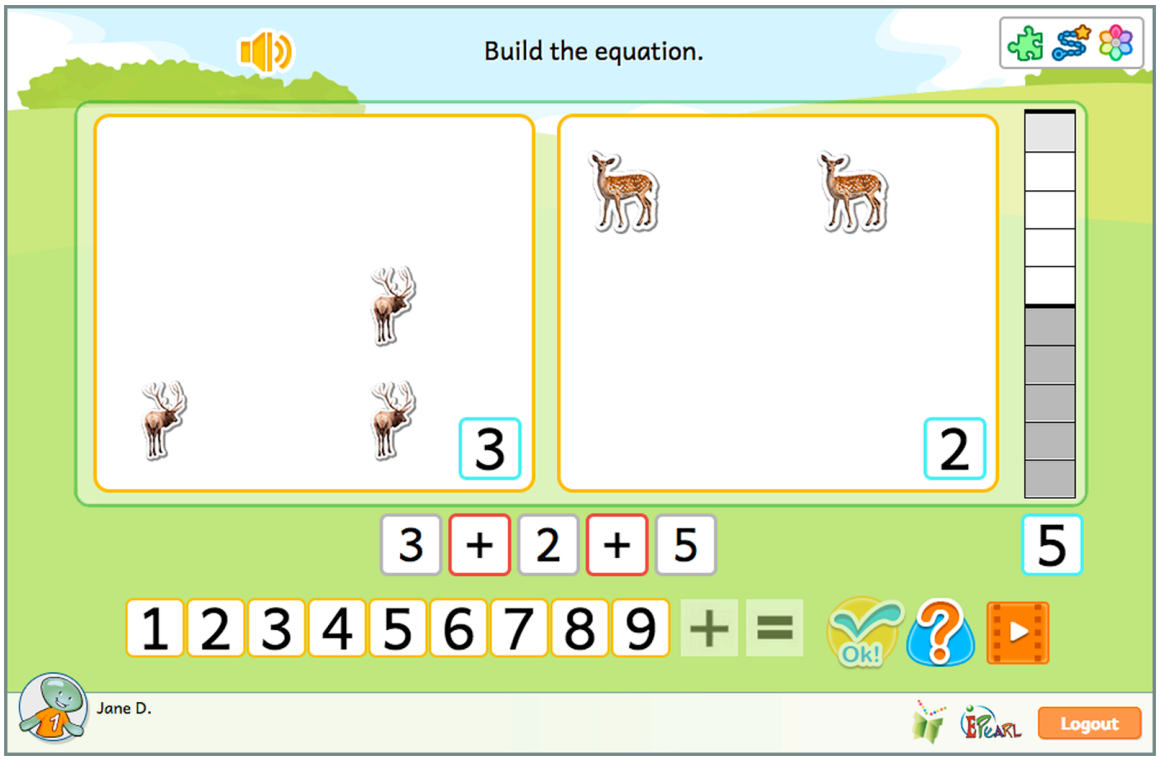


Figure 41: Add Step 3 – Incorrect Feedback Example in Phase 3

Step 4

In this step, students are provided an equation and are asked to create sets of animals to match it. The student must select a box before they can add deer to that set. The tool will not allow them to add more than nine in total. ELM will accept answers that are flipped from the provided arrangement, such as when the software provided the equation of 1+2=3 and the student create sets of 2+1=3.

Figure 42: Add Step 4

Incorrect Feedback

If the student added fewer than asked for, the software will add "ghost" deer to the set. If the student added too many deer, the software will highlight the deer that should have been added to show there are too many in the set. If the student makes an error in both sets, the software will show the feedback sequentially. Following these visuals, the sum will be highlighted in the total counter. In all of these situations, there is additional situational audio to help pinpoint how the student can correct their error.

Figure 43: Add Step 4 - Incorrect Feedback Example of Too Many Deer Added

Subtract

Subtraction is introduced as the process of taking away. In all five of the Subtraction steps, the student will initially see all animals in one set. They have to count how many are in the set and note the empty second set. This way, the student learns to associate 0 as the count of the empty set. In the later steps, this process will be associated with an equation. This equation is a symbolic representation of the state of the sets, and the 'take away' process that occurred.

Step 1

The student is introduced to the concept of subtraction (take away) by being asked to move objects from one pile to another. Zero (0) is introduced as the count for an empty set.

Figure 44: Subtract Step 1, Phase 1

Incorrect Feedback

In the first phase, if the student makes an error by not correctly counting the animals, the barn's counter will highlight cells to match the student's incorrect answer. The student can then compare their answer to the coloured cells in the counter.

If the student makes an error in the second phase, then the number in Chuck's speech bubble gets lager and the number associated with the pasture is red. If the student sends fewer goats to the pasture than asked for then Chuck tells them they need to send more. If the student sends more than asked for then Chuck informs them that they sent too many over.

Figure 45: Subtract Step 1, Phase 2 - Incorrect Feedback Example of Sending Too Many

Step 2

This step builds on the previous one. The student is expected to count the number of animals in the barn, as well as the empty pasture by recording the count as 0. Then the student once again “takes away” by moving animals from one set to another. The software introduces symbolic representation for the process, in the form of an equation that is automatically updated as the student moves animals.

Teacher Tip: As students begin to learn about mathematics, they are more likely to see equations expressed a - b = c but ELM's Subtraction steps expresses the equation as c = a - b. This is due to the visual nature of the activities. The left-side barn is associated with the "c" position while the right-side pasture is associated with the "b" position and the total of all animals is associated with the "a" position. The steps begin with all animals in the left-side barn and the equation appears before students begin to move the animals. As they move the instructed amount to the right-side pasture, they can observe the cells in the barn and pasture's counters adjust, while the total remains the same. Writing the equation as c = a - b helps students to see how changes they are making change the equation.

Students with learning difficulties may have trouble understanding that a – b = c is the same as c = a – b. If you normally use manipulatives with a blank equation, you can show them that it is the same by rotating the manipulative 180 degrees. Alternatively, you can use a balanced scale as a metaphor to demonstrate that it does not matter which side the components are on so long as the scale is balanced.

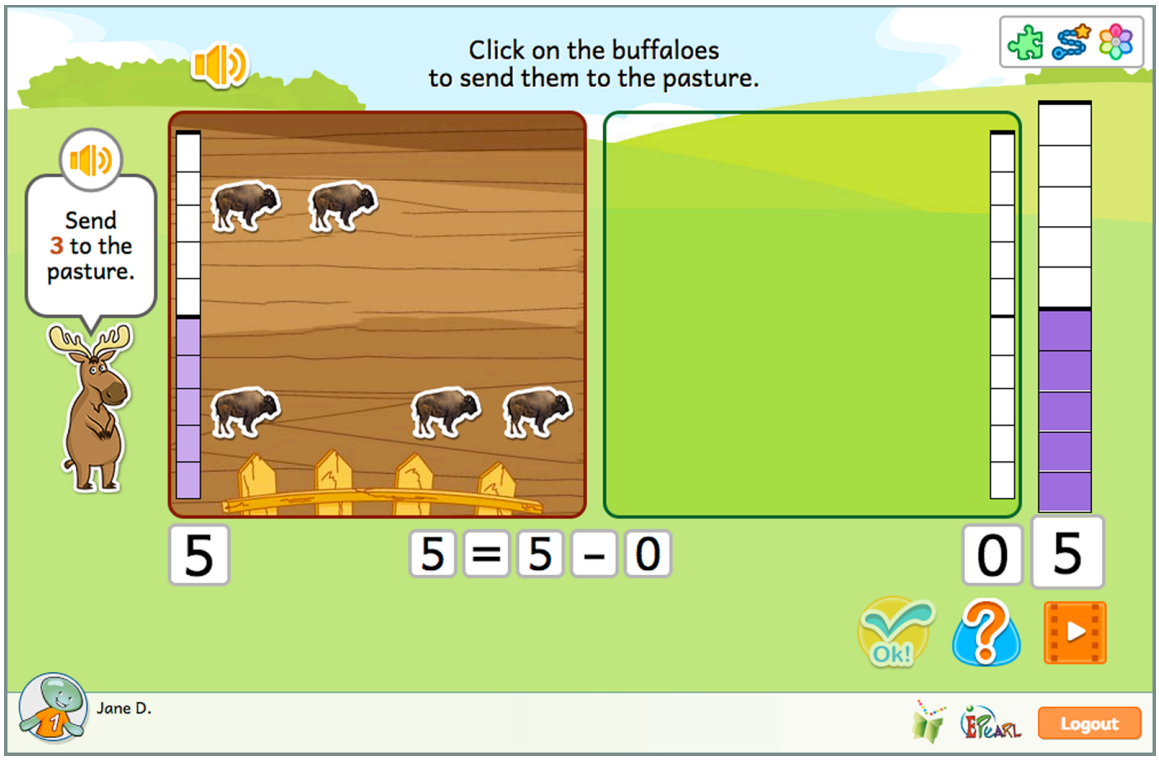


Figure 46: Subtract Step 2, Phase 2

Incorrect Feedback

As with the previous activity, the feedback in phase 1 allows students to compare their answer with the number in the counter. The barn's counter and/or the pasture's counter will highlight cells to match their answer. The student can then compare their answer to the coloured cells in the counter. If there are errors in both areas, the feedback happens simultaneously.

If the student makes an error in the second phase, then the number in Chuck's speech bubble gets larger and the number associated with the pasture is red. If the student sends fewer buffaloes to the pasture than asked for then Chuck tells them they need to send more. If the student sends more than asked for then Chuck informs them that they sent too many over.

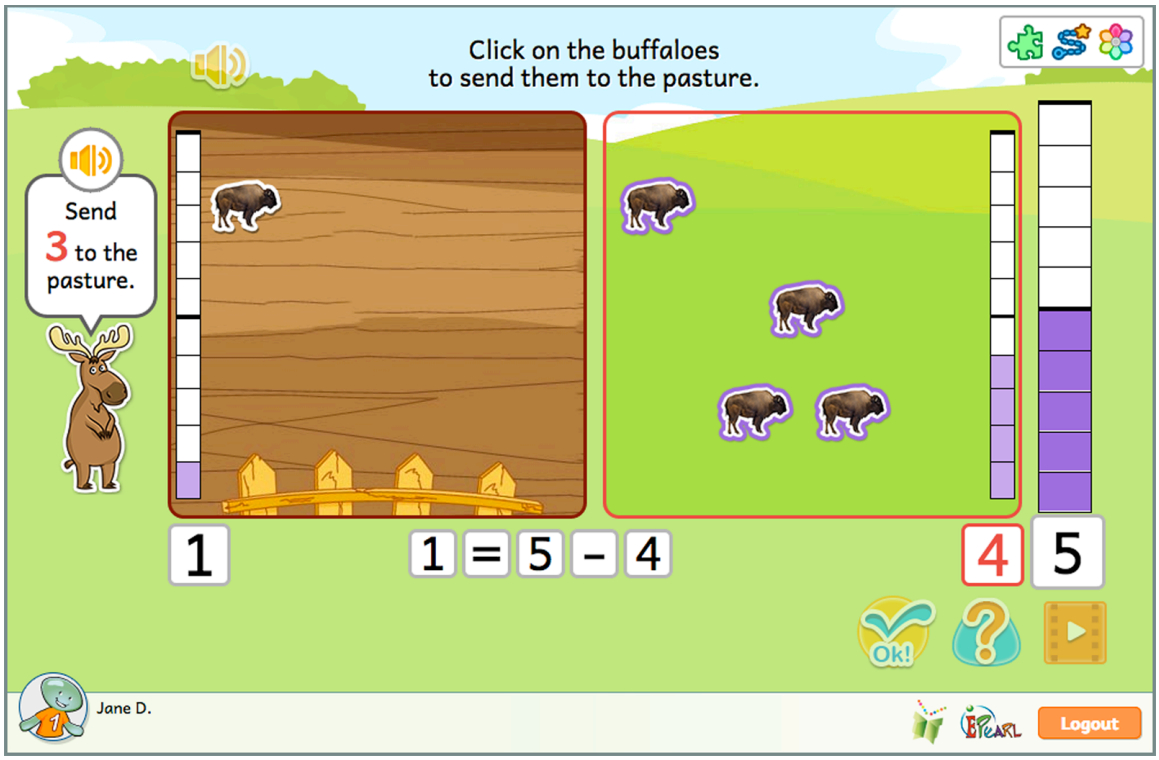


Figure 47: Subtract Step2, Phase 2 - Incorrect Feedback Example of Sending Too Many

Step 3

As with the first two steps, the student must first indicate how many animals there are in the barn and in the pasture. They implement the 'take away' strategy by moving the requested amount of animals into the pasture. However, the software no longer automatically updates the equation based on the animals' movement. Instead, it is up to the student to correct the equation.

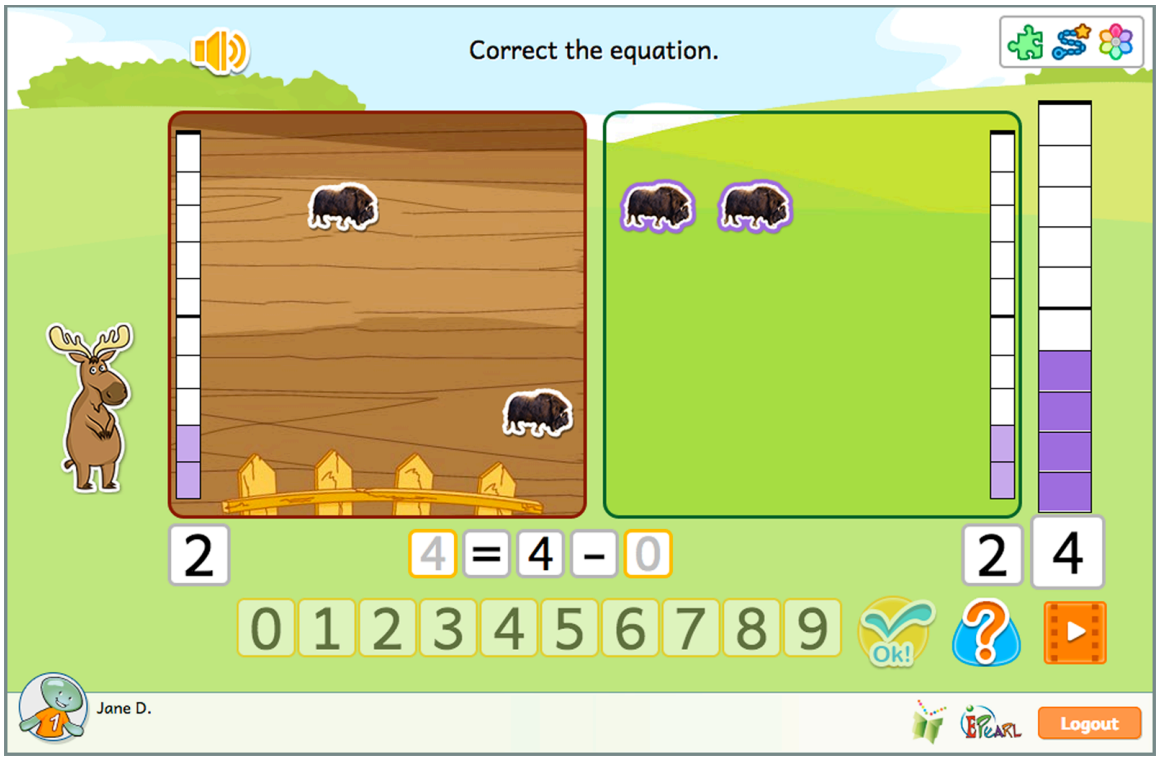


Figure 48: Subtract Step 3, Phase 3

Incorrect Feedback

As with the previous activity, the feedback in phase 1 allows students to compare their answer with the number in the counter. The barn's counter and/or the pasture's counter will highlight cells to match their answer. The student can then compare their answer to the coloured cells in the counter. If there are errors in both areas, the feedback happens simultaneously.

If the student makes an error in the second phase, then the number in Chuck's speech bubble gets larger and the number associated with the pasture is red. If the student sends fewer muskoxen to the pasture than asked for then Chuck tells them they need to send more. If the student sends more than asked for then Chuck informs them that they sent too many over.

In the third phase, if the student does not properly adjust the equation then the associated number boxes for the barn and pasture will be highlighted as errors in the equation.

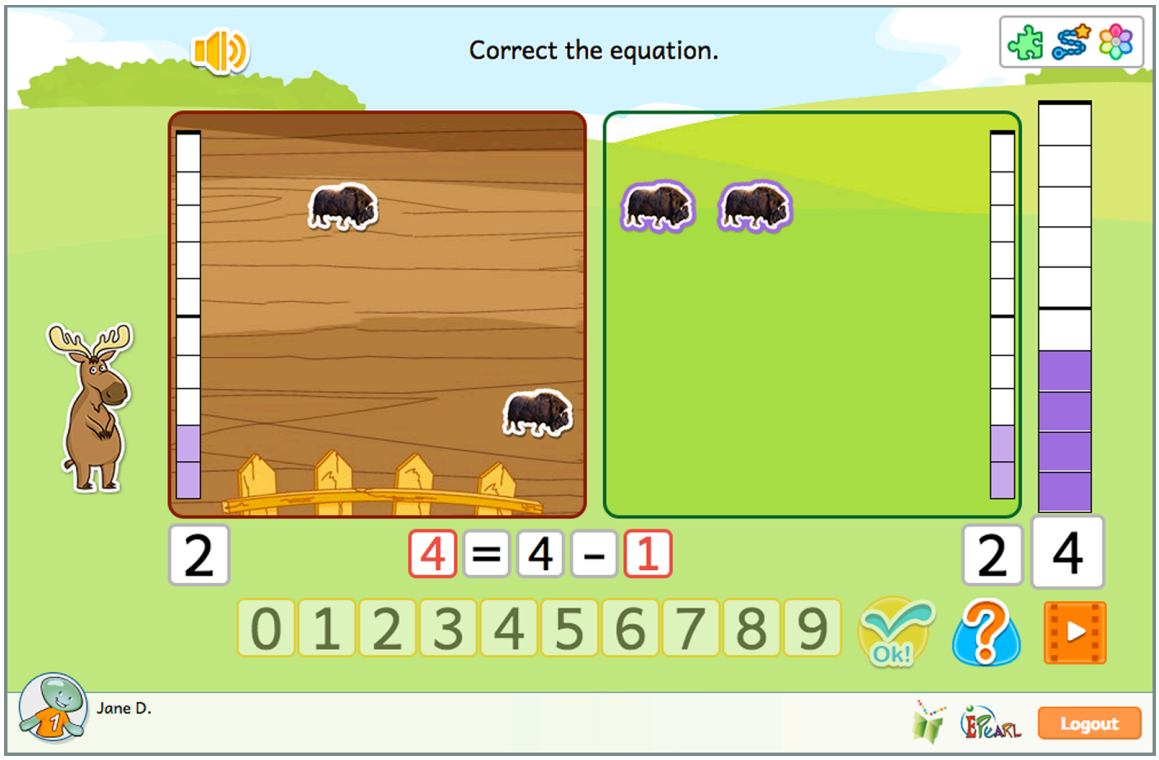


Figure 49: Subtract Step 3, Phase 3 - Incorrect Feedback Example

Step 4

This activity focuses on “counting up”, which is a use of addition to perform subtraction. The previous three steps used the ‘take away’ strategy to move animals from one location to another, which kept the total unchanged. However, in this step, the student adds new animals to one location, to reach a requested total.

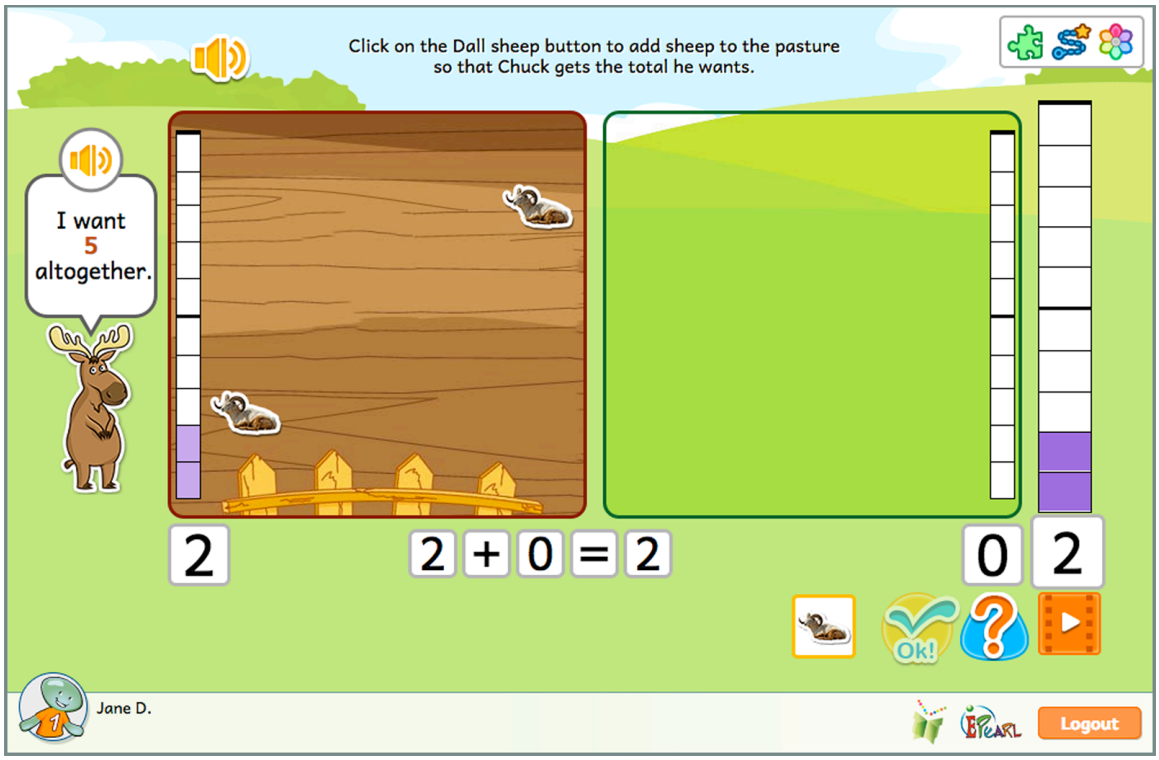


Figure 50: Subtract Step 4, Phase 2

Teacher Tip: You may question why this activity isn't part of the Add steps, given that the student adds animals to the screen. There are various ways in which a student could understand the process of subtraction, and many students use "adding up" to do subtraction. This particular activity is designed to allow students to see that they can use adding up just like subtraction and get the same result.

Incorrect Feedback

As with the previous activity, the feedback in phase 1 allows students to compare their answer with the number in the counter. The barn's counter and/or the pasture's counter will highlight cells to match their answer. The student can then compare their answer to the coloured cells in the counter. If there are errors in both areas, the feedback happens simultaneously.

If the student makes an error in the second phase, then the number in Chuck's speech bubble gets larger and the number in the total box is red. If the student sends fewer Dall sheep to the pasture than asked for then Chuck tells them they need to send more. If the student sends more than asked for then Chuck informs them that they sent too many over.

In the third phase, if students do not properly adjust the equation then the barn and pasture's number boxes will be highlighted as the errors in the equation.

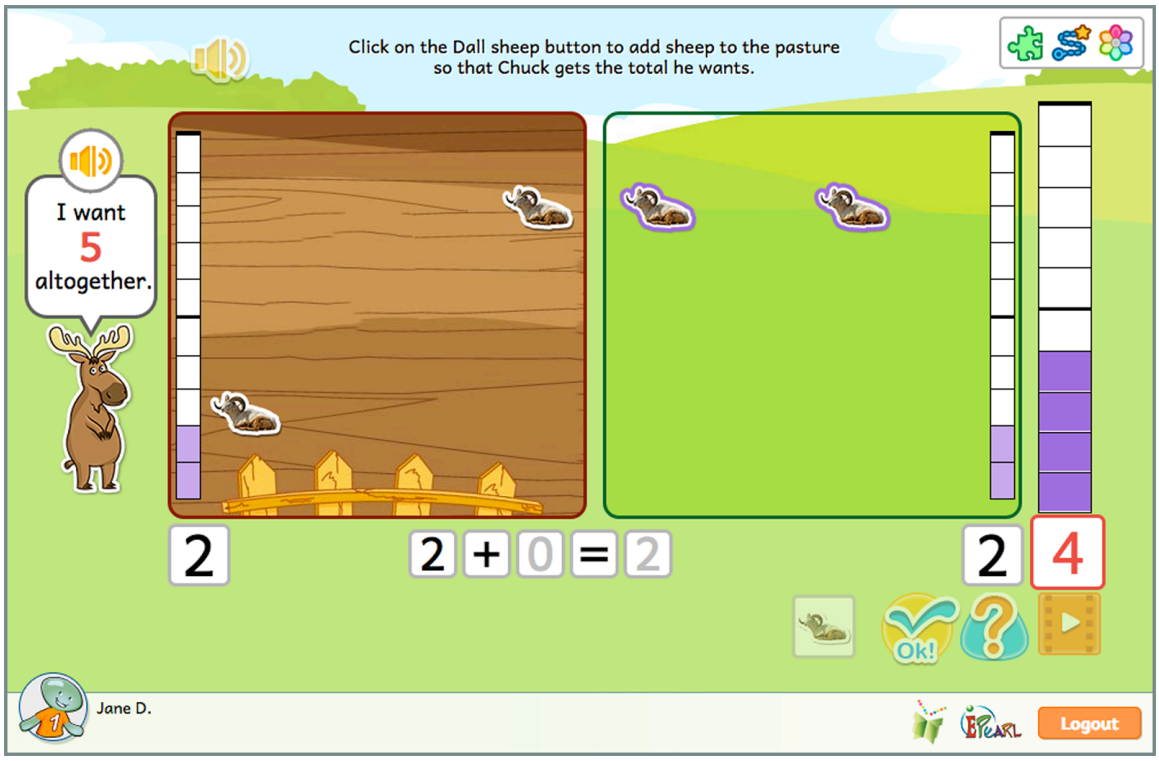


Figure 51: Subtract Step 4, Phase 2 - Incorrect Feedback Example

Step 5

This step is similar to steps 1-3, however, Chuck specifies how many should remain in the barn rather than go to the pasture.

Figure 52: Subtract Step 5, Phase 2

Incorrect Feedback

As with the previous activity, the feedback in phase 1 allows students to compare their answer with the number in the counter. The barn's counter and/or the pasture's counter will highlight cells to match their answer. The student can then compare their answer to the coloured cells in the counter. If there are errors in both areas, the feedback happens simultaneously.

If the student makes an error in the second phase, then the number in Chuck's speech bubble gets larger and the number associated with the pasture is red. If the student sends fewer sheep to the pasture than asked for then Chuck tells them they need to send more. If the student sends more than asked for then Chuck informs them that they sent too many over.

In the third phase, if students do not properly adjust the equation then the barn and pasture's number boxes will be highlighted as the errors in the equation.

Figure 53: Subtract Step 5, Phase 2 - Incorrect Feedback Example

Decompose

The main concept of this Idea is integer decomposition or partition. These steps allow students to practice counting strategies, as well as the operations of addition and subtraction. Students are presented with a set of beavers. They must partition this total by separating the beavers into two different sets by deciding which beavers are in the grass or water region. The later steps include a table where students are tasked with completing the missing line. This demonstrates their understanding of the patterns in the table by selecting a missing value.

Teacher Tip: The notion of having the beavers in the dam or water is expressed by whether they are seen standing on grass or surrounded by water. They do not move to the dam or water boxes. The reason for this is because keeping them in one line maintains the notion that they are one unit/group. So even though they are being partitioned into subgroups, remaining in a line at the bottom of the screen reinforces the idea that they are one group.

Step 1

The student is presented with a set of beavers and asked to partition them into two subsets based on the numbers they are shown. They click on as many beavers as indicated that ought to go swimming (i.e. partition them). This will provide grounding for subsequent student understanding of the task of decomposing a positive integer into a sum of two integers.

Figure 54: Decompose Step 1

Incorrect Feedback

If they made an error by not selecting enough beavers then all of the beavers already selected plus additional beavers still in the dam that would make up the difference turn red. If they made an error by selecting too many beavers then the number of selected beavers equal to what should be in the water turn red. The user can then compare this to the additional beavers they chose to send swimming.

Figure 55: Decompose Step 1 - Incorrect Feedback Example of Too Few Selected

Figure 56: Decompose Step 1 - Incorrect Feedback Example of Too Many Selected

Step 2

This step introduces a decomposition table. The student is again presented with a set of beavers, but is now asked to partition them into two subsets based on the highlighted line in the table. The number of beavers in the dam is given but the number of beavers swimming is missing from the table. They first click on as many beavers as indicated that ought to go swimming (i.e. partition them). Once they do this correctly, they enter the numerical value to complete the table. They are expected to do this twice in order to complete the set.

Teacher Tip: The student is provided with two opportunities to decompose a given number because it provides more practice with that particular number, increasing the chance that the students will notice the pattern in that decomposition, as well as gain fluency in decomposing that number.

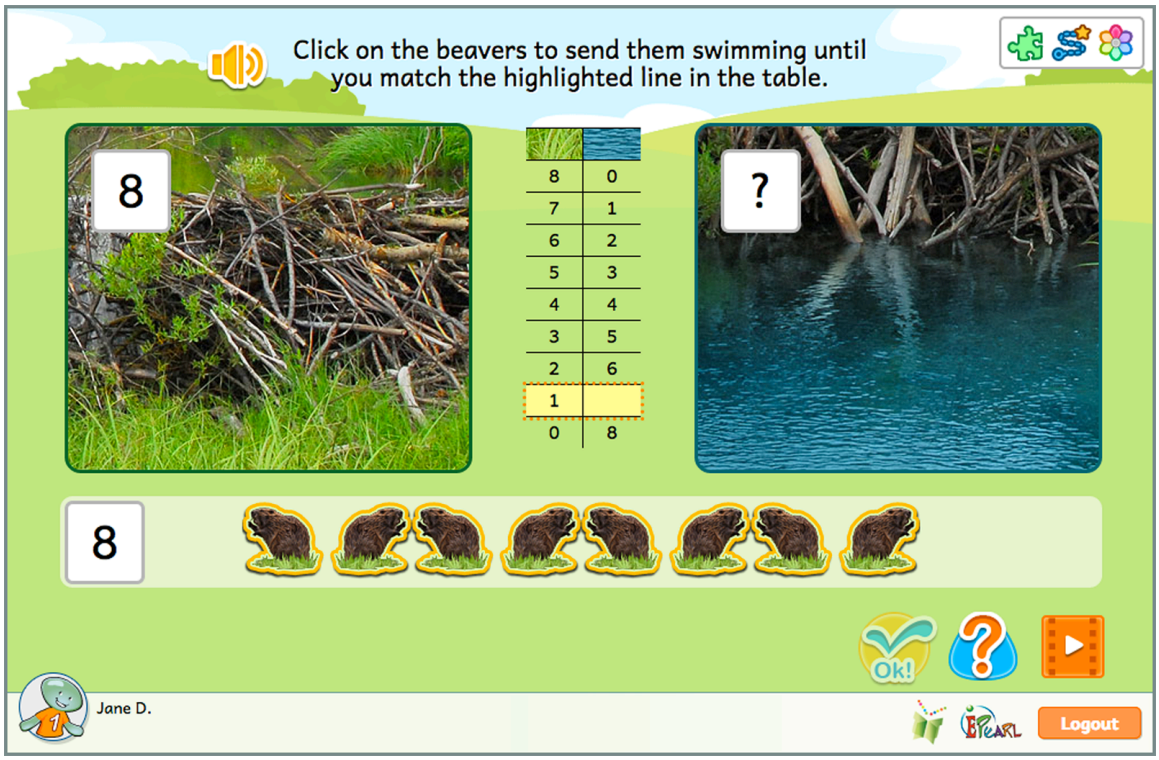


Figure 57: Decompose Step 2

Teacher Tip: Students with difficulties may have trouble understanding this table because they are not used to reading vertically. Present them with a number line or a ruler where they would be familiar with a horizontal method of counting. Turn the manipulative to show them it can be read vertically in both directions as well.

Incorrect Feedback

The first phase is the same as the previous activity. If they made an error by not selecting enough beavers then all of the beavers already selected plus additional beavers still in the dam that would make up the difference turn red. If they made an error by selecting too many beavers then the number of selected beavers equal to what should be in the water turn red. The user can then compare this to the additional beavers they chose to send swimming.

In the second phase if they enter a number that is less than the number of beavers that are swimming, then beavers equal to the number they entered are encircled in red. The student can see that some of the beavers swimming have not been counted. If the student entered a number larger than the beavers that are swimming, then all of the beavers in the water are encircled in red plus some of the beavers in the dam to that the total number of beavers highlighted equals the student's incorrect answer. If they enter a number larger than the total number of beavers then the number in the total box is highlighted, becomes larger and wiggles.

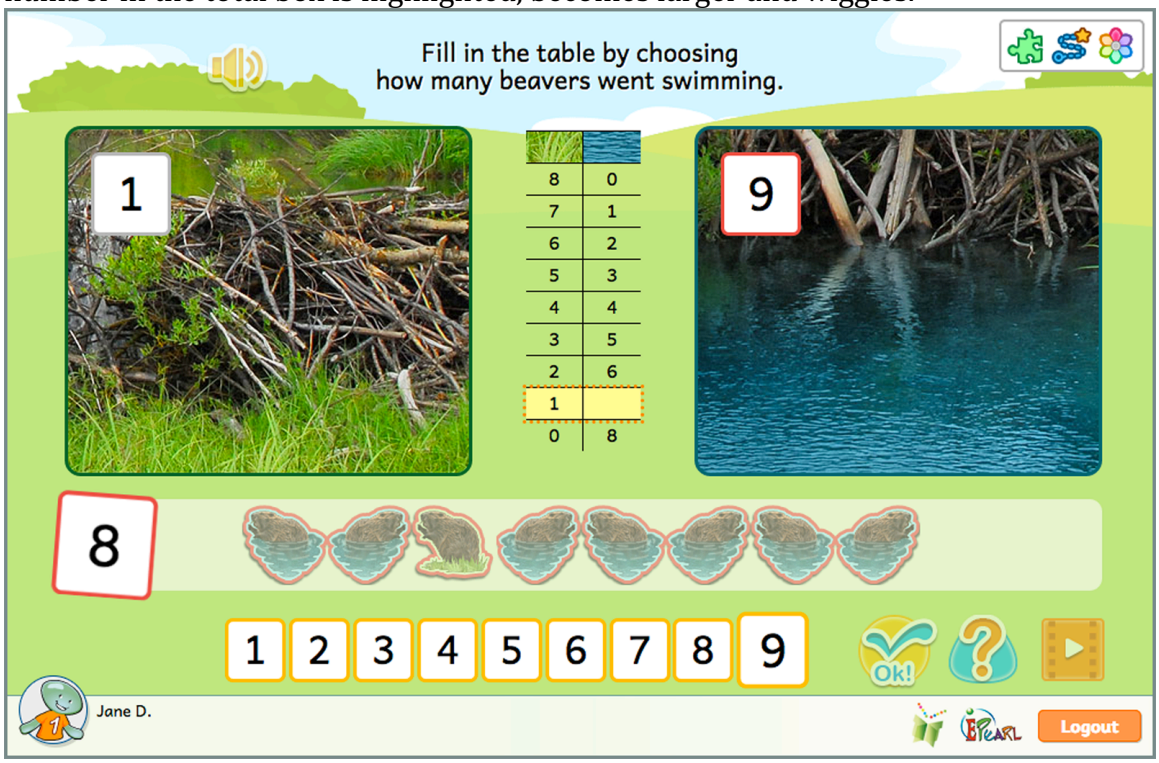


Figure 58: Decompose Step 2, Phase 2 - Incorrect Feedback Example of an Answer Larger Than Total

Step 3

This step builds on the previous one and the student is now asked to fill in both numbers in the missing row. They begin by indicating how many of the beavers ought to remain in the dam based on the missing row. As they select a number, the beavers below are automatically partitioned so long as they do not choose a number larger than the total beavers shown. The student can use this to evaluate their answer. If they answer this correctly, the previous partition fades and they are then asked to indicate how many are swimming based on the missing cell. As they enter a number, the beavers are once again partition below as a visual aid.

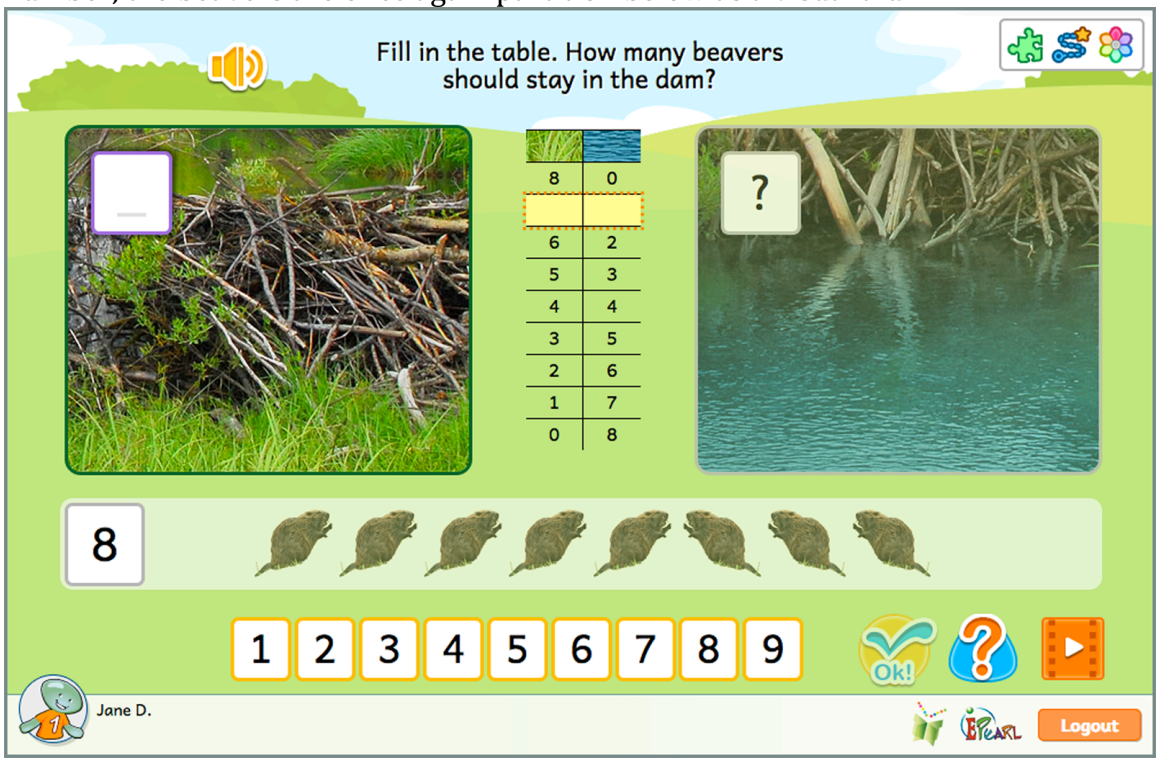


Figure 59: Decompose Step 3

Incorrect Feedback

In the first phase, if the student provided an incorrect number that that appears elsewhere in the table, that row is highlighted. If the student provided an answer that is higher than the largest number in the table, additional ghost beavers will appear below to equal the total erroneous answer. The total number box will get bigger and wiggle. Students can compare their answer to the total number box.

In the second phase, if the user enters an incorrect number, the total box is highlighted, becomes larger and wiggles. The beavers will temporarily disappear and the total box will move to the right side of the screen. The numbers from the dam and water boxes float down to create the statement that the number in the dam plus the number the student entered does not equal the total.

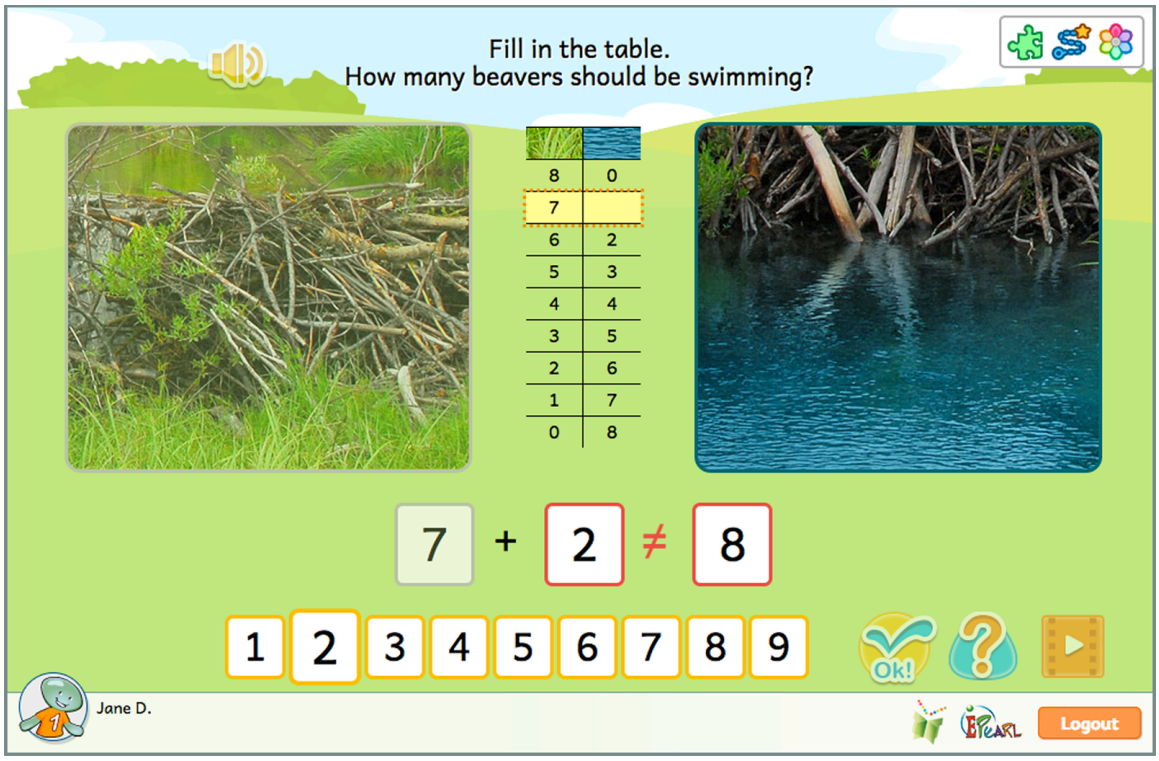


Figure 60: Decompose Step 3, Phase 2 - Incorrect Feedback Example

Step 4

This step also asks students to fill in a missing row in the decomposition table but this time without the beavers present as scaffolding. They also fill in both cells at once.

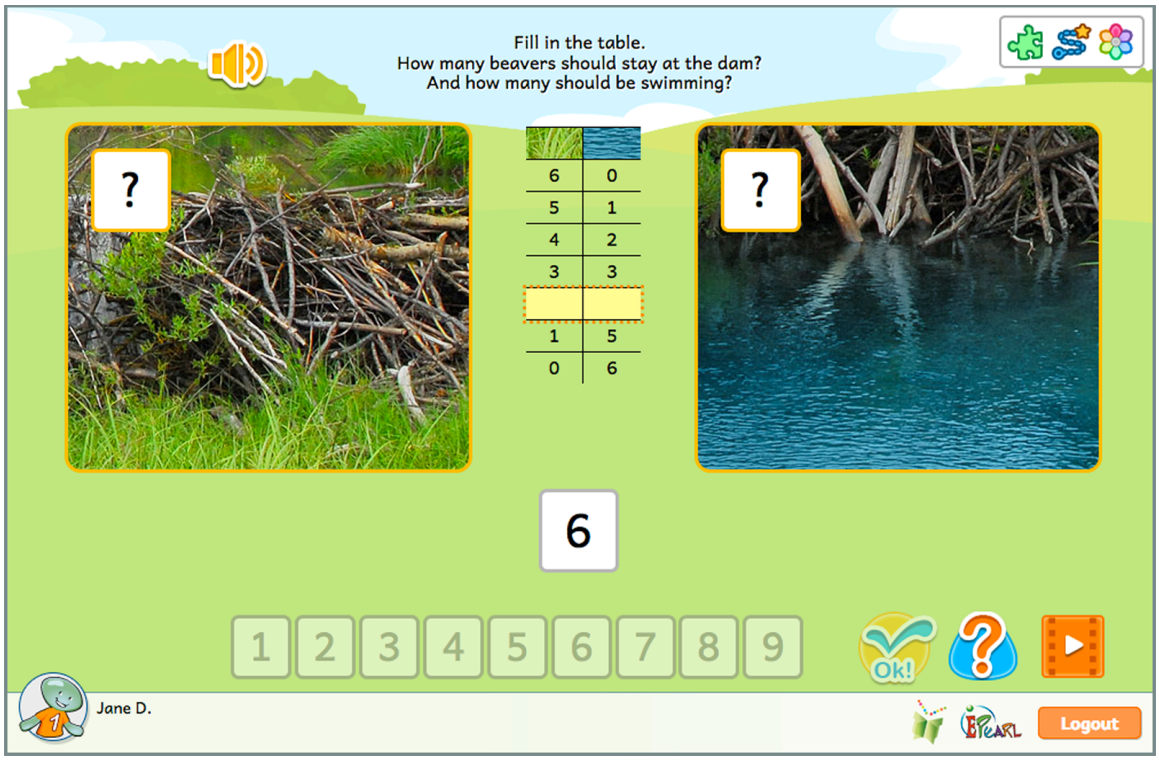


Figure 61: Decompose Step 4

Incorrect Feedback

If the student provided a partition of the total, but not the one asked for, the related line in the table will be highlighted and wiggle. If the student enters numbers that are not a partition of this number then the total box is highlighted, becomes larger and wiggles. It will move to the right side of the screen. The numbers from the dam and water boxes float down to create the statement that the number in the dam, plus the number the student entered does not equal the total.

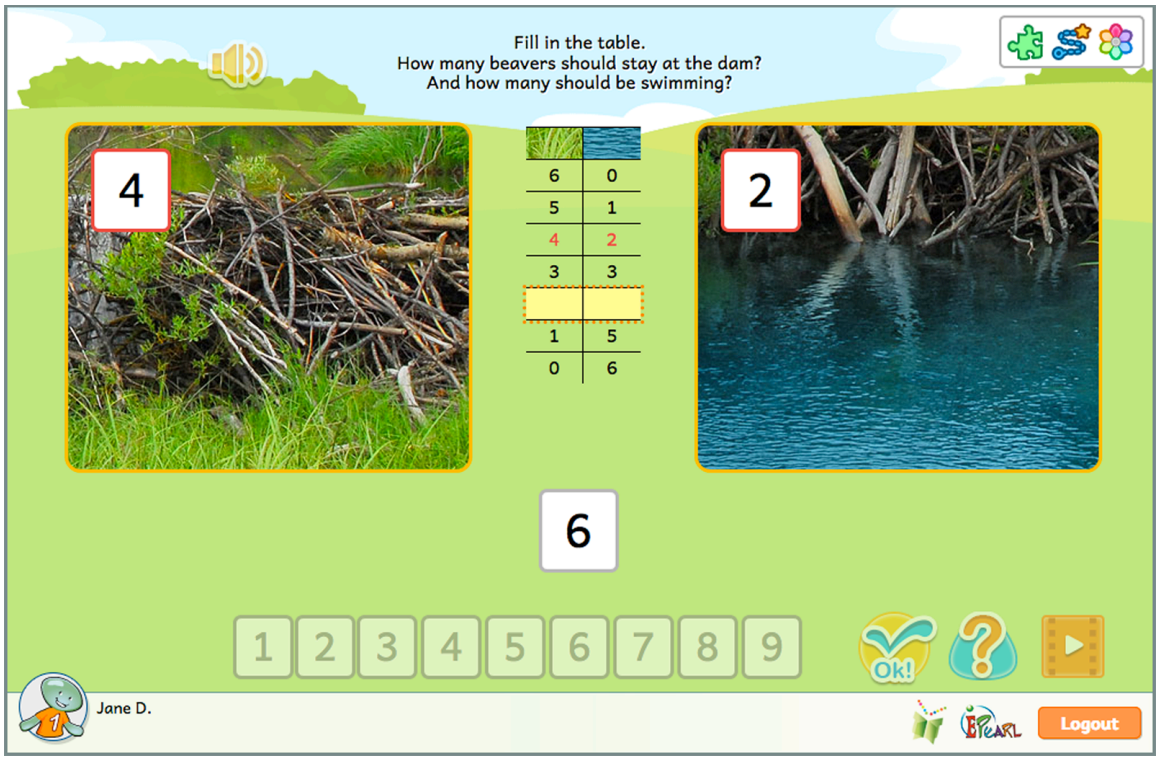


Figure 62: Decompose Step 4 - Incorrect Feedback Example of Providing a Non-Asked for Partition

Place Value

The Place Value steps aim to help students realize that numbers beyond 9 but less than 100 have two 'parts': there is a number of '10s' combined with a number of '1s'. The goal is to have students understand that one 'ten' is equal to ten 'ones'. This combined number is read left (tens) to right (ones).

In order to facilitate students' grasping the notion of place value, ELM's steps associate tens to trees. When ten units - represented as pinecones - are grouped, they become a tree.

Step 1

Building on the strategy of using counters to count, the Place Value steps extend this notion to represent two-digit numbers with counters. Students are shown between 1-29 pinecones in the field. If the number they are shown is above 10, then groups of ten will be compiled together in the shape of a tree. In this step, the tool provides enough counters to count all of the pinecones shown. When the student provides the correct answer, the pinecones fly to the counters. Any counters that have 10 pinecones transforms into a tree. If there are two they merge into one 'tree' counter, which introduces students to the idea of using a tens counter to count.

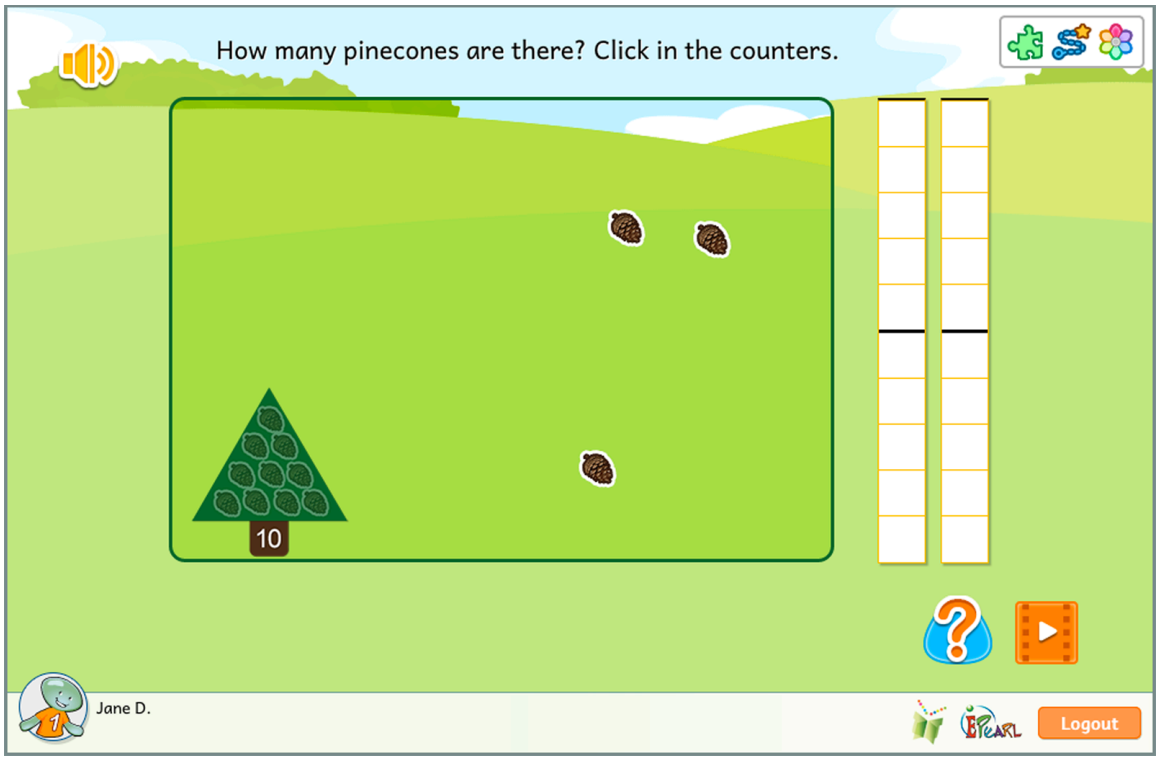


Figure 63: Place Value Step 1

Incorrect Feedback

If the student makes an error, the tool will encircle the counter's cells up to the number of pinecones visible. The student can then compare their answer to what's shown.

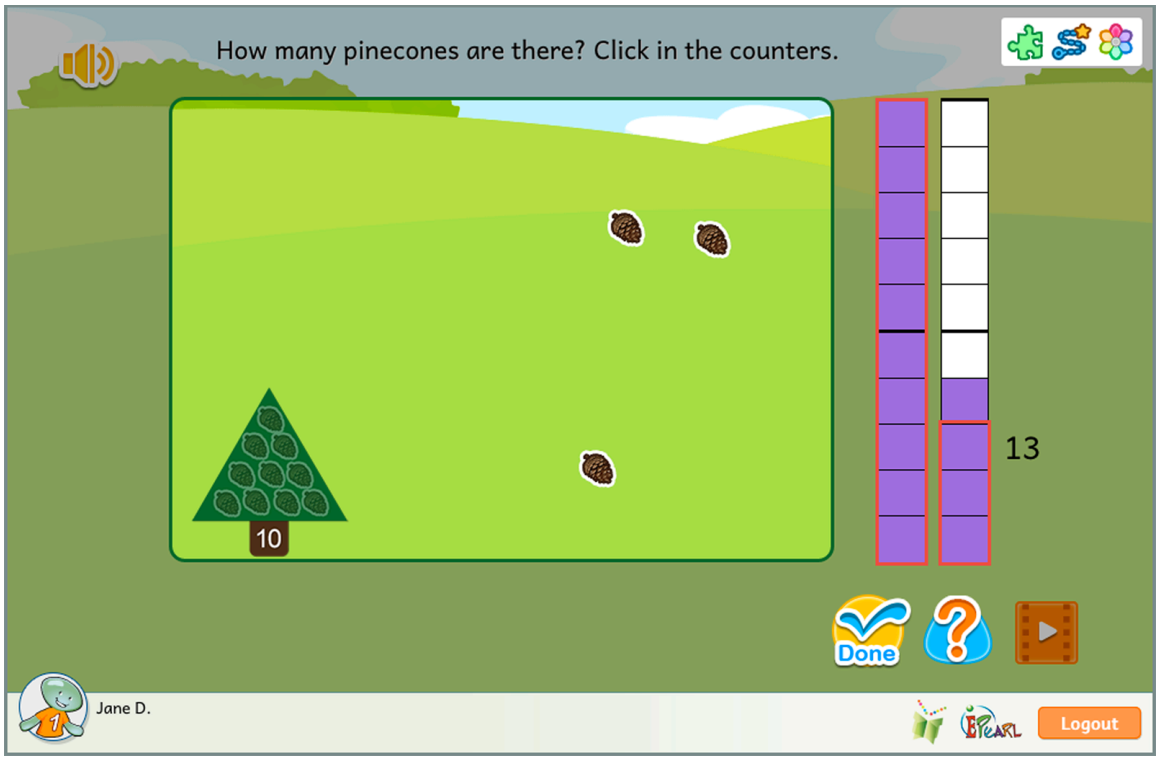


Figure 64: Place Value Step 1 - Incorrect Feedback Example

Step 2

Building on the previous step, students are once again asked to count the number of pinecones there are but this time they are required to first determine how many counters they will need. Initially there are no trees shown even if there are ten or more pinecones. Instead, groups of 5 are clustered together to help students count. For the students that struggle with counting, the pinecones will merge into a tree after they make their first error.

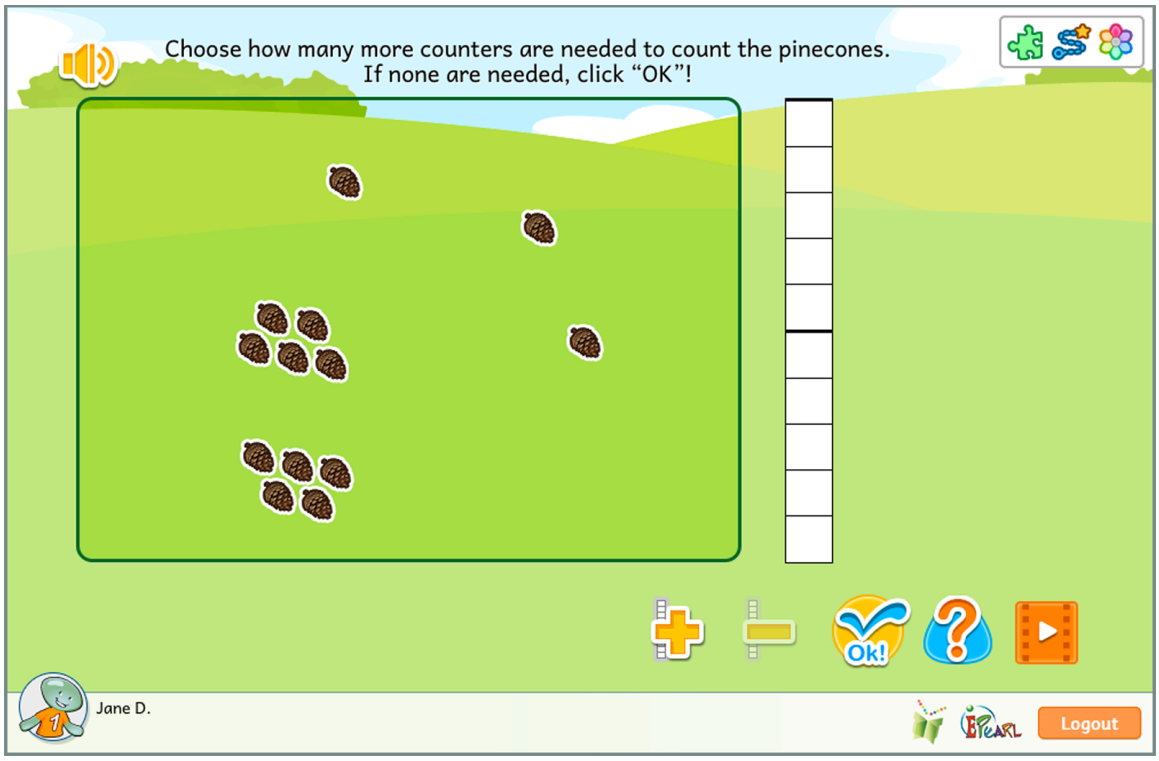


Figure 65: Place Value Step 2

Incorrect Feedback

During the first phase, the pinecones will attempt to fill the counters. If the student does not add enough counters to count all of the shown pinecones then some pinecones will remain in the field and turn red. If they added too many counters then they will see that there are some empty counters with nothing in them.

If the student makes an error in the second phase, the tool will encircle the counter's cells up to the number of pinecones visible. The student can then compare their answer to what's shown.

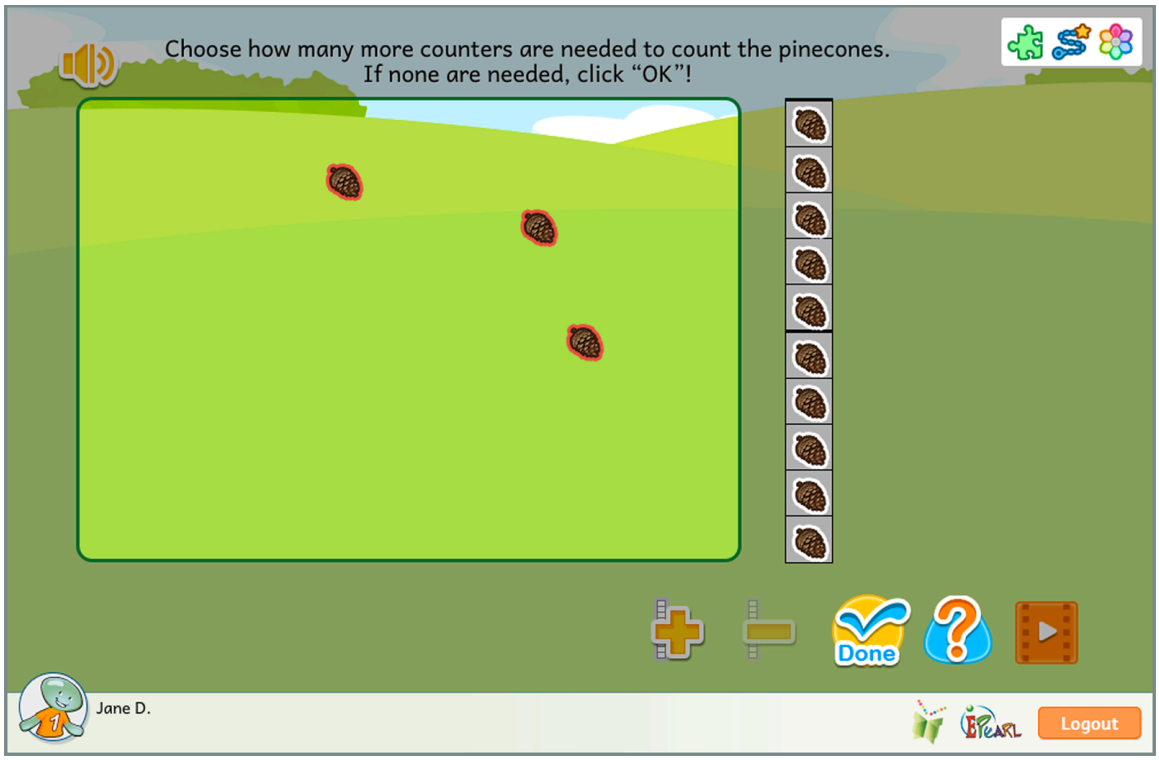


Figure 66: Place Value Step 2, Phase 1 - Incorrect Feedback Example of Not Enough Counters

Figure 67: Place Value Step 2, Phase 1 - Incorrect Feedback Example of Too Many Counters

Step 3

This step connects the tree counter (tens) and a pinecone counter (ones) with the corresponding abstract symbolic representation. First, the student is asked how many 'trees' (tens) need to be added to the tree counter in order to count all of the pinecones shown. The goal is to have students recognize that two digit numbers are grouped in "tens" and this corresponds to the numeral in the "tens" place. Once they correctly indicate how many trees should be added to the tens counter, they are asked to select the correct numeral to represent the total count of pinecones.

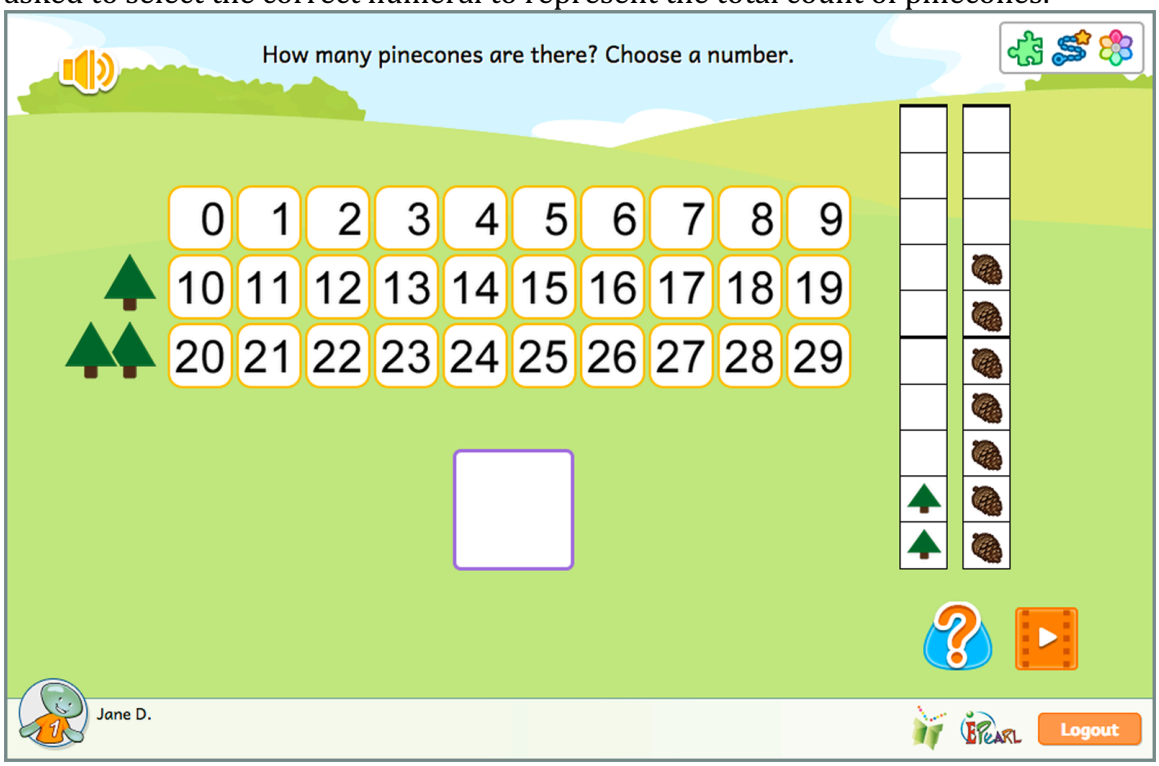


Figure 68: Place Value Step 3, Phase 2

Incorrect Feedback

In phase 1, if the student does not add enough trees in the 'tree' counter, groups of ten will merge into a tree and become red. If they add too many trees, the counter's cells up to how many trees are visible are encircled. The student can compare their answer to what is highlighted. If they did not need to add trees but did so anyway, the tool will display faded red trees equal to the number they indicated.

In phase 2, the counters will surround the cells to indicate the incorrect number. The student can then compare their answer to where the trees and pinecones appear.

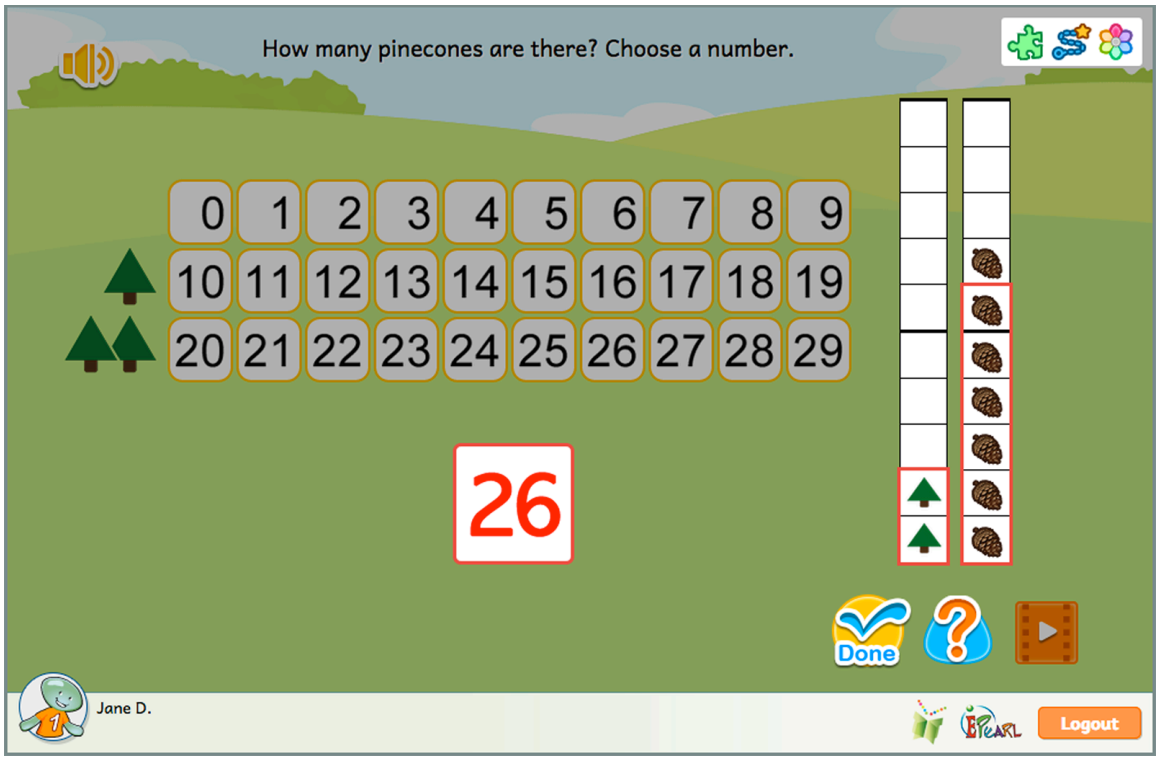


Figure 69: Place Value Step 3, Phase 2 - Incorrect Feedback Example

Step 4

This step asks students to write two-digit numbers, by entering the numeral for the tens position and ones position separately. If there are no trees then the student ought to enter 0, but by the end of the step, the tool will also show them that a zero is the tens position does not need to remain – i.e. 0# is the same as saying just #.

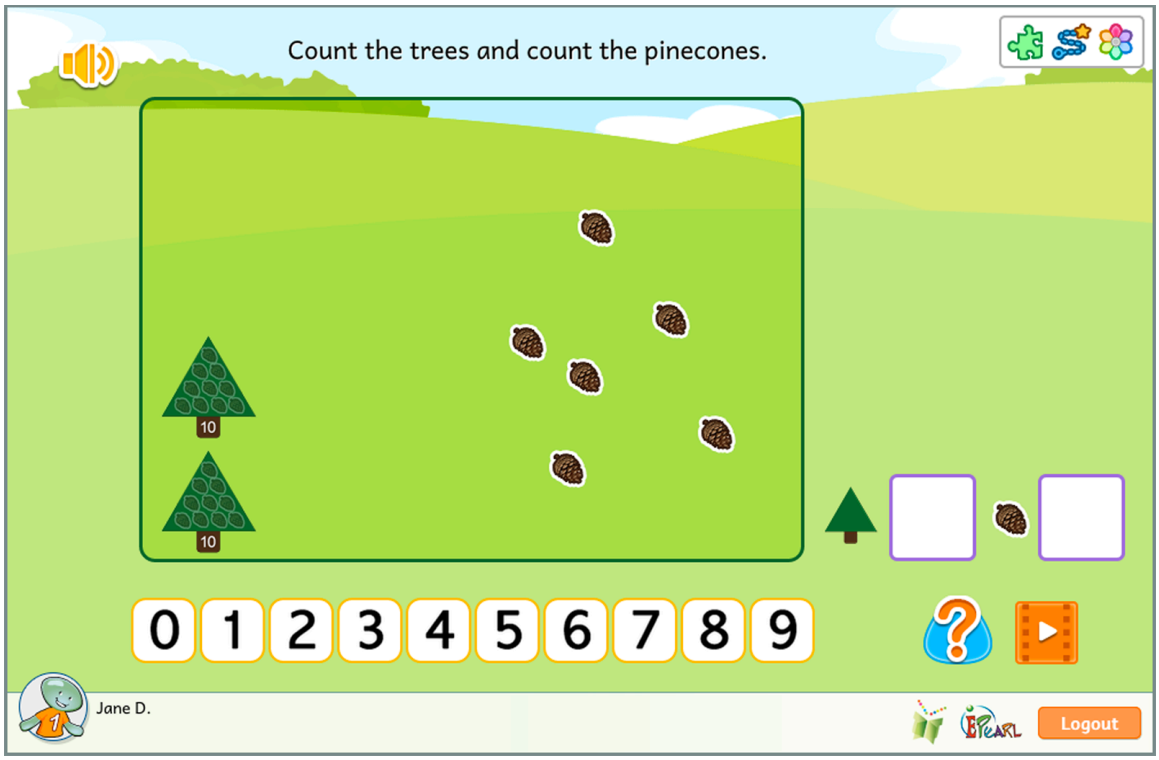


Figure 70: Place Value Step 4

Incorrect Feedback

If the student makes an error in the tens position by entering a number larger than the correct digit, then transparent red trees appear on screen to show what their incorrect number would look like. If the student entered a 1 in the tens position when the answer should be two, one of the trees is highlighted while the other is not. If the student made an error in the ones position by entering a number smaller than what is in the field, pinecones equal to student's answer are highlighted. The rest remain untouched so that students can compare their answer. If the entered a number larger than what is in the field, then transparent red pinecones will appear to visually display what their answer looks like.

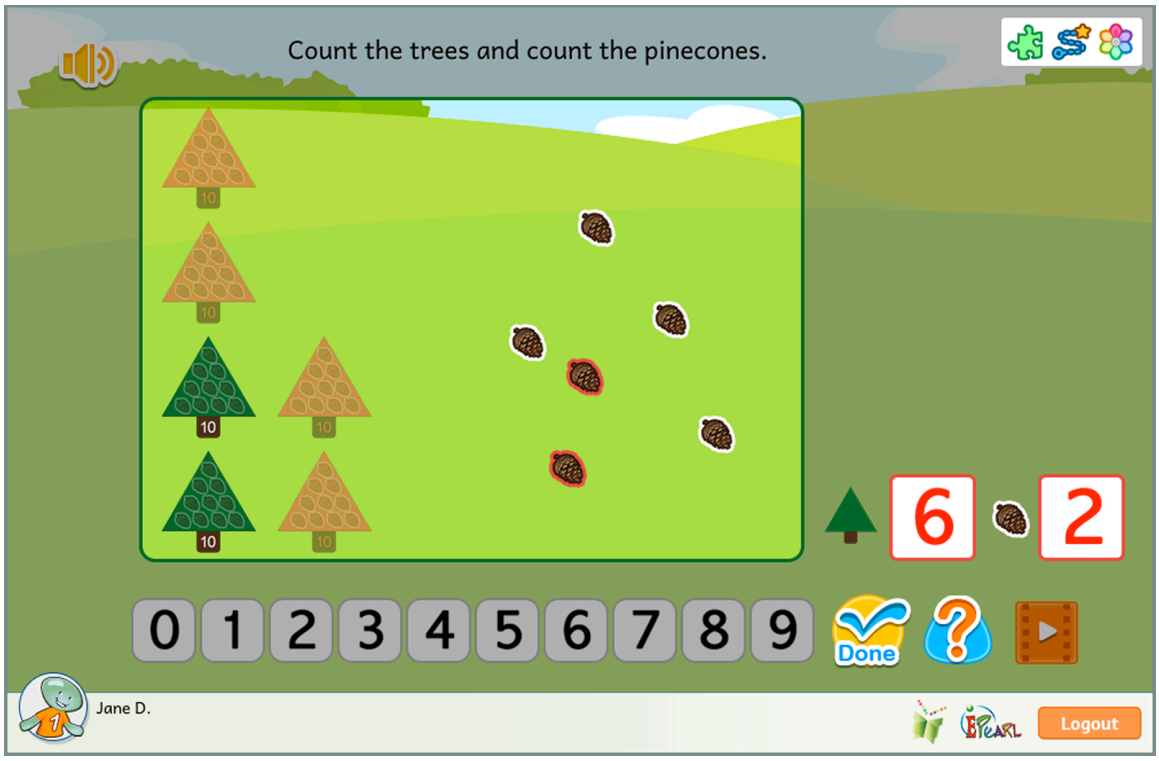


Figure 71: Place Value Step 4 - Incorrect Feedback Example

Step 5

This step is similar to the previous one, but the student is asked to enter the tens and ones position into one number box. The number will be between 1-99.

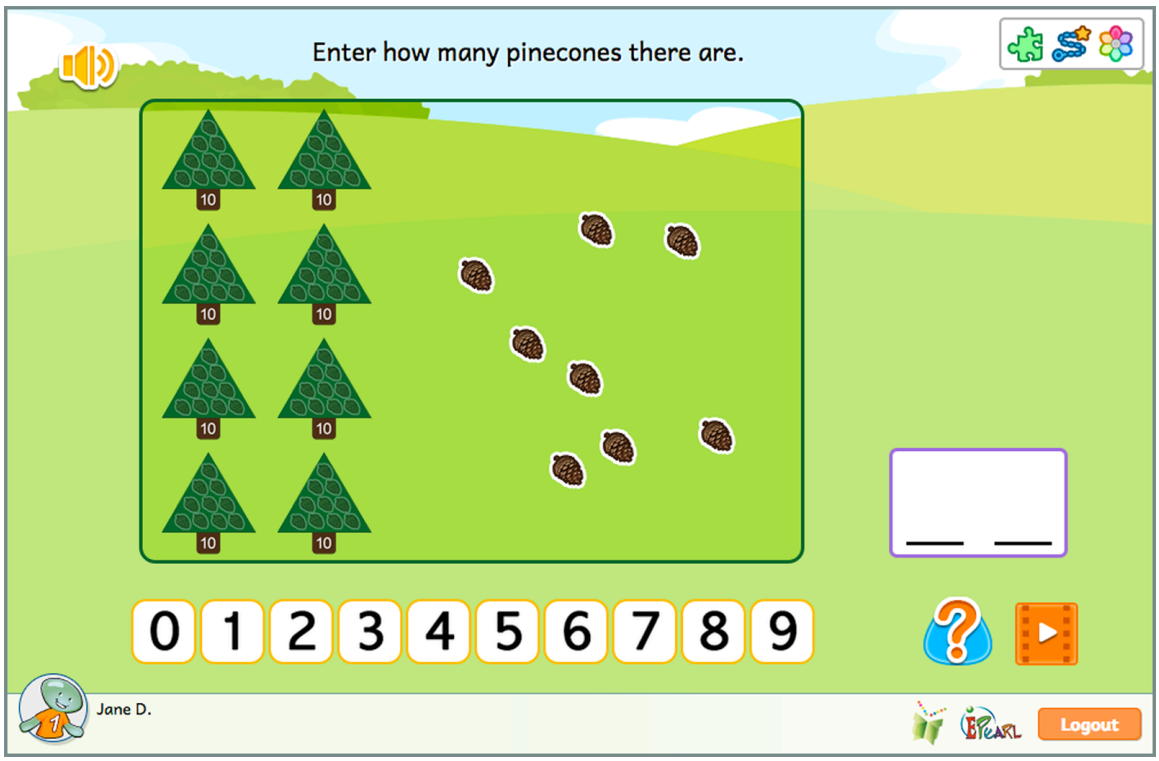


Figure 72: Place Value Step 5

Incorrect Feedback

If the student makes an error by entering a number smaller than what is on the field, the trees or pinecones equal to the student's answer are highlighted. The rest remain untouched so that students can compare their answer. If the entered a number larger than what is in the field, then transparent red trees or pinecones will appear to visually display what their answer looks like.

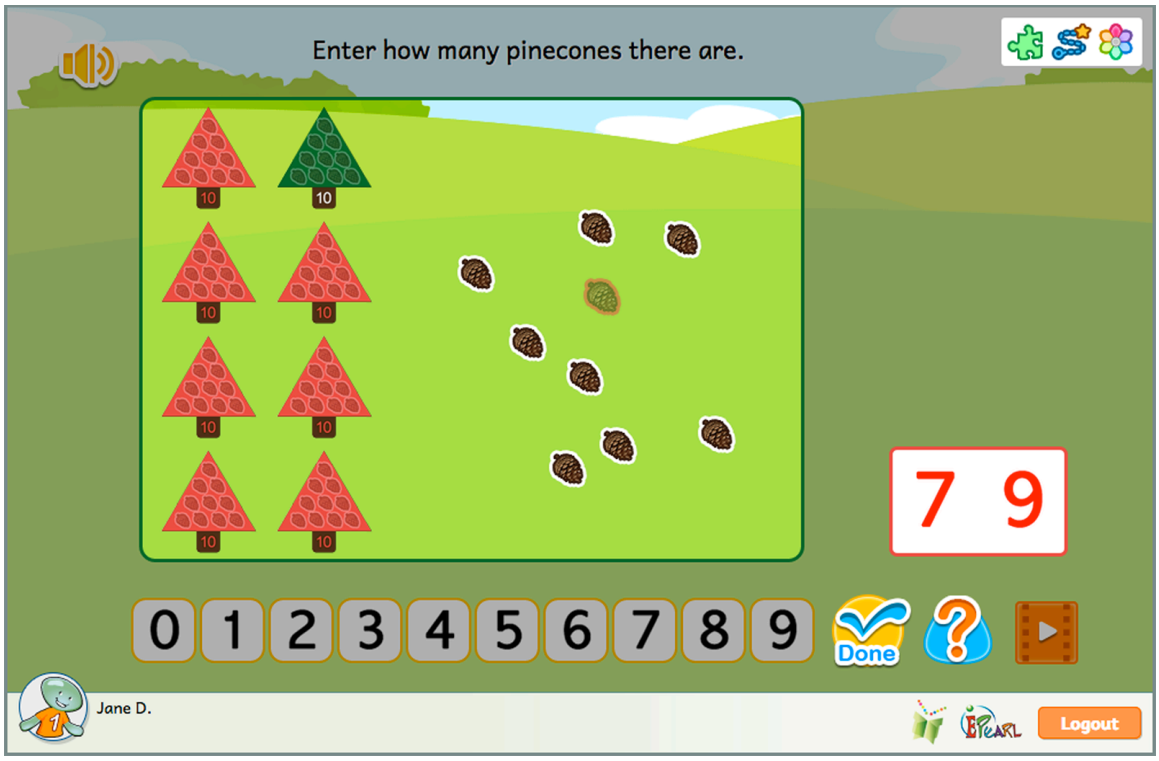


Figure 73: Place Value Step 5 - Incorrect Feedback Example

Step 6

This step reverses the process of the previous ones but providing the student with a number and asking them to place equivalent trees and pinecones in the field. In other words, they are asked to demonstrate their understanding of a two-digit numbers (an abstraction) by creating an image that expresses each digit (semi-abstract). They are asked to place the trees (tens) first. Once they answer this correctly, they are asked to add the pinecones (ones).

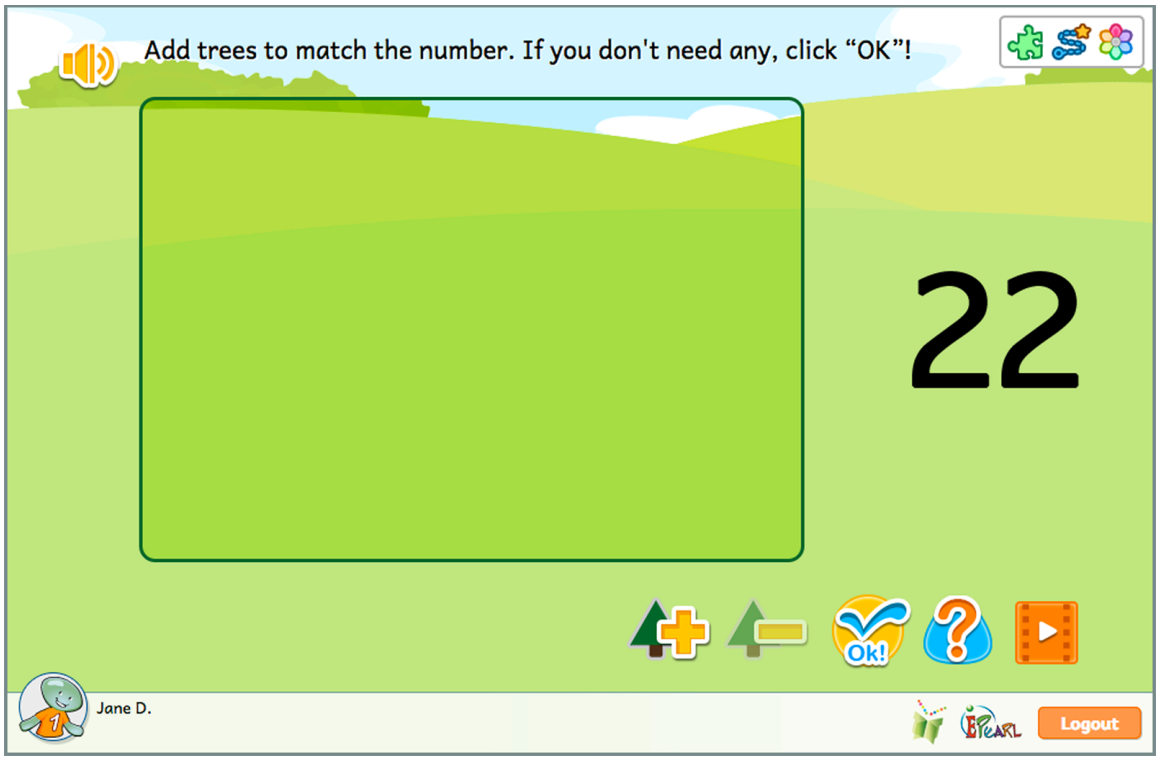


Figure 74: Place Value Step 6

Incorrect Feedback

If the student makes an error, a tree and a pinecone number box appears on screen to indicate the number the student provided. The student can then compare their answer with what was asked for.

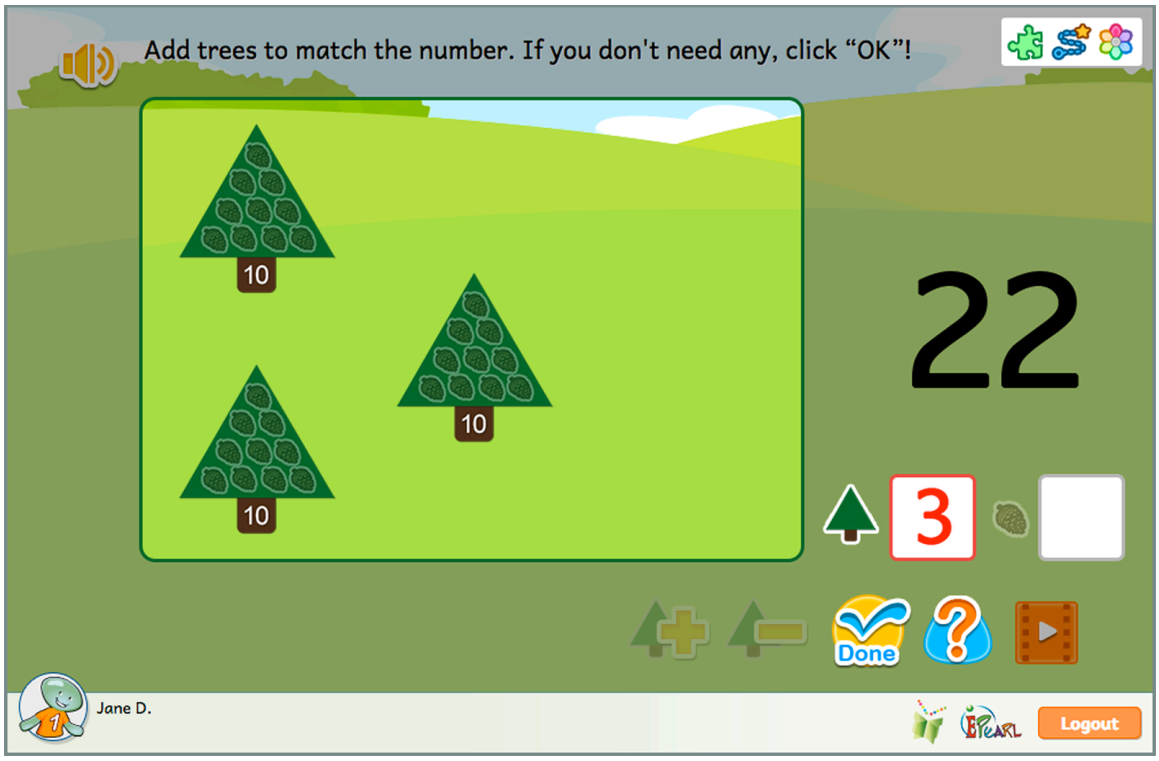


Figure 75: Place Value Step 6, Phase 1 - Incorrect Feedback Example

Step 7

This step aims to encourage students' fluency with performing addition and subtraction. The student practices decomposition within a memory card game structure.

Teacher Tip: We repeat decomposition at this juncture because it is a skill that is essential to one way that students may perform rapid and accurate addition/subtraction involving numbers of two or more digits. For example, when asked to compute 13 - 8 the student knows that 8 cannot be subtracted from 3. Instead, the student decomposes the 10 into 8 and 2, and understands that after subtracting 8 what is left is 2+3 = 5.

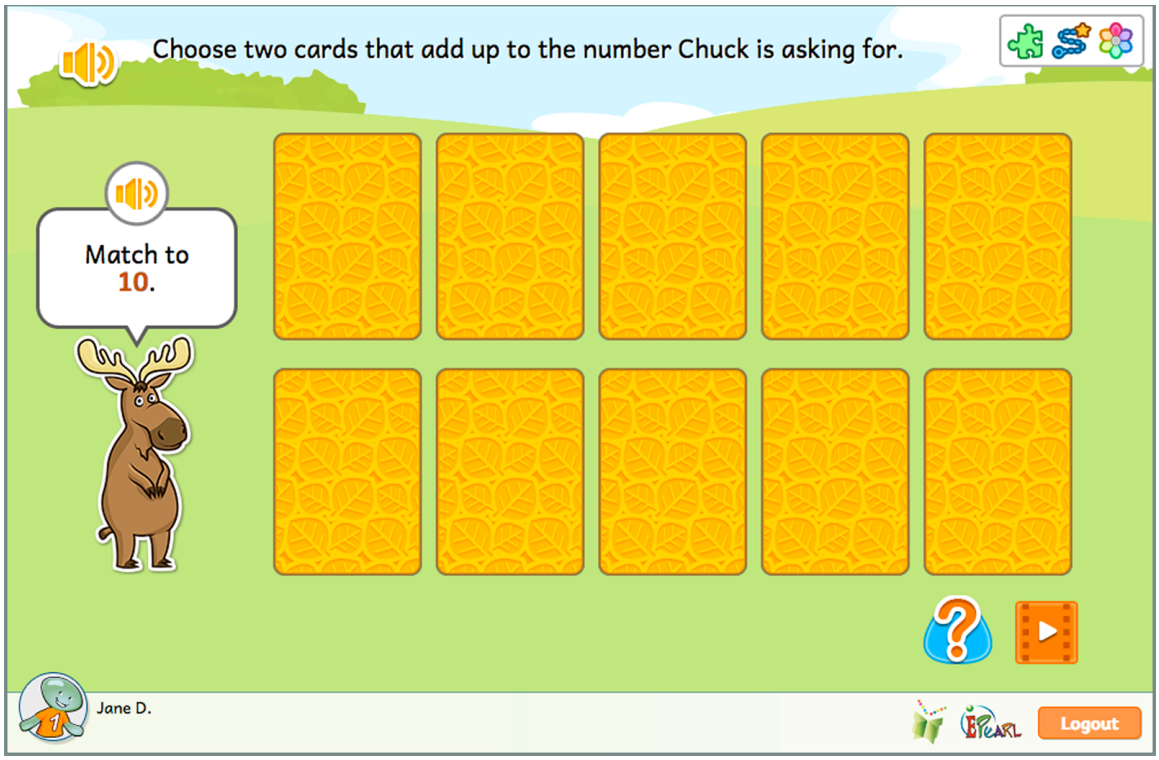


Figure 76: Place Value Step 7

Incorrect Feedback

If the student attempts to match two cards that are not a partition of the number asked for, then an equation appears at the bottom of the screen to add these two cards. The student can then compare the total of the two cards to the number that Chuck is asking for.

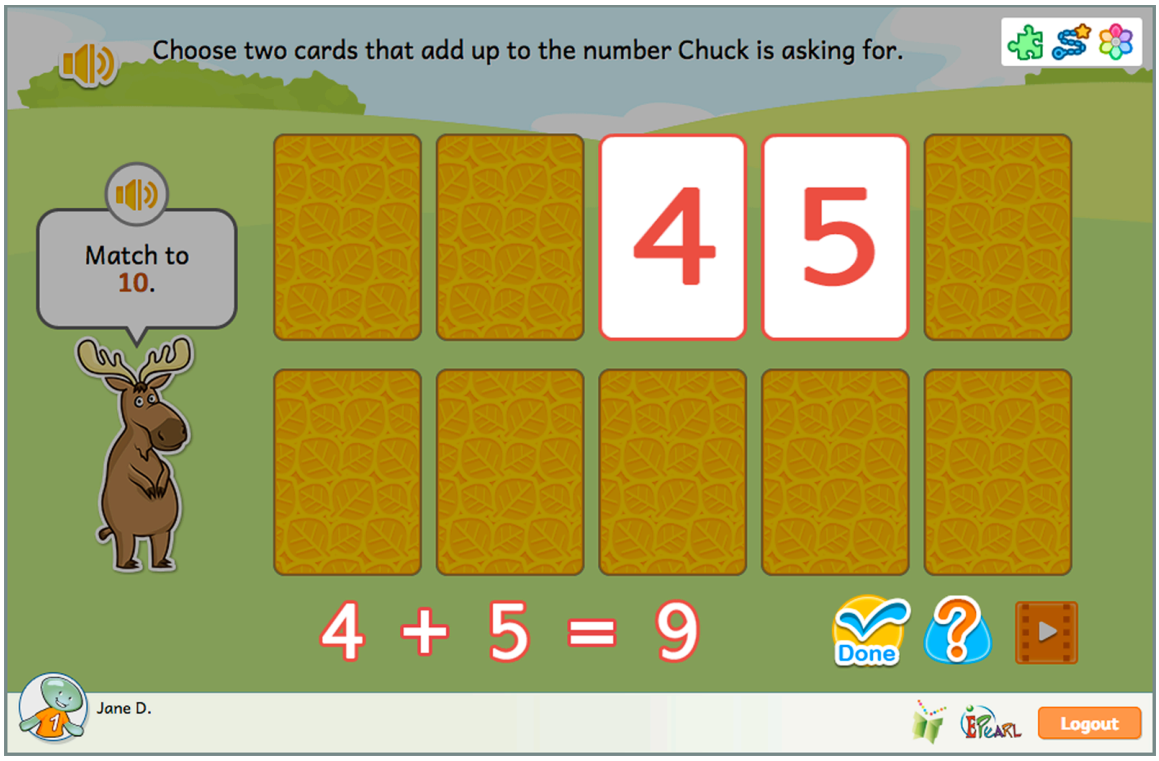


Figure 77: Place Value Step 7 - Incorrect Feedback Example

Step 8

This step has the student add a one-digit number to a two-digit number. The student does so by adding pinecones from one counter into a second group of counters. If their addition results in a counter with ten pinecones, they must convert that counter into a tree (i.e. add it to the tens place). Once they have correctly joined the both groups, they are asked to represent this process by writing the equation. Half the time, the student will be asked to write the equation a + b = c and the other half of the time, it will be presented as c = a + b.

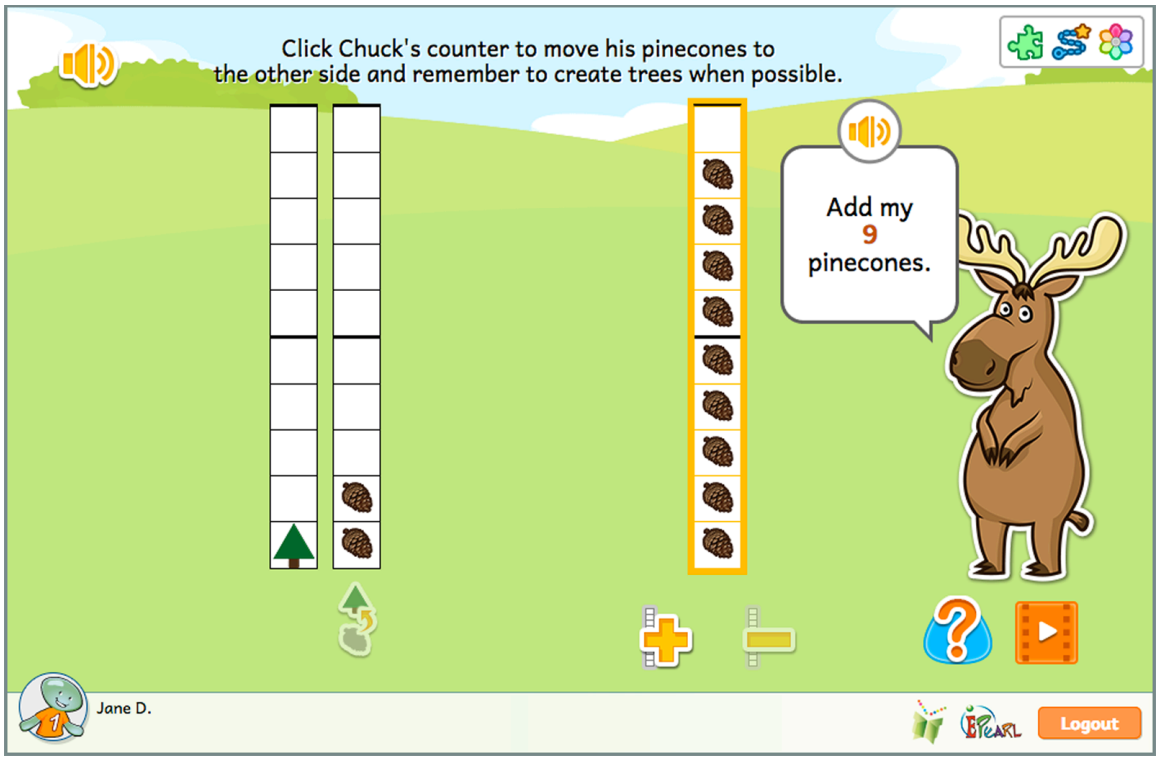


Figure 78: Place Value Step 8, Phase 1

Incorrect Feedback

There are several different types of errors a student can make in the first phase. If the user did not move all of the pinecones in Chuck's counter, those pinecones will be highlighted. If there is no more room in the counters for them, meaning that the student has to add a counter, this button will also be highlighted in case the error is related to technical difficulties. If they unnecessarily added an extra counter, it will be highlighted and Chuck will prompt them to consider if it's needed. If the student has a counter will 10 pinecones and they did not transform it into a tree, the tool will play a brief animation showing that process before it reverts back to the student's answer. If the student made multiple errors then the feedback for each type is shown sequentially.

If the student made an error during the second phase, ELM will use the counters to help students see the mistake. If the digit the student entered is less than the trees/pinecones in the counter, then the cells surrounding up to that number are highlighted. The student can then compare their answer to where the trees and pinecones appear. If the student entered a digit larger than the trees/pinecones in the counter, then additional transparent trees/pinecones appear in the counter to indicate what the student's answer would look like. If the student mixed up the tens place and the ones place, a double-sided arrow will appear below the digits as well. If the student made multiple errors then the feedback is shown sequentially from left to right, focusing on one number at a time.

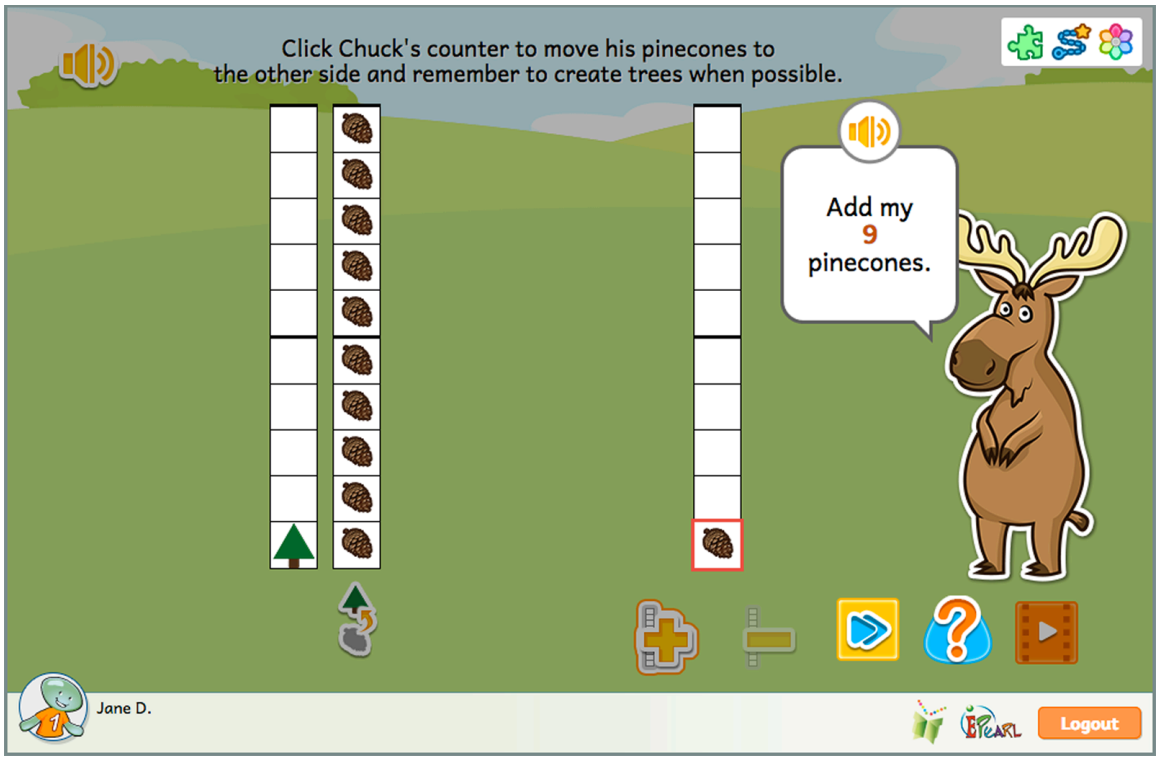


Figure 79: Place Value Step 8, Phase 1 - Incorrect Feedback Example of Not Adding Enough Counters to Move All Pinecones

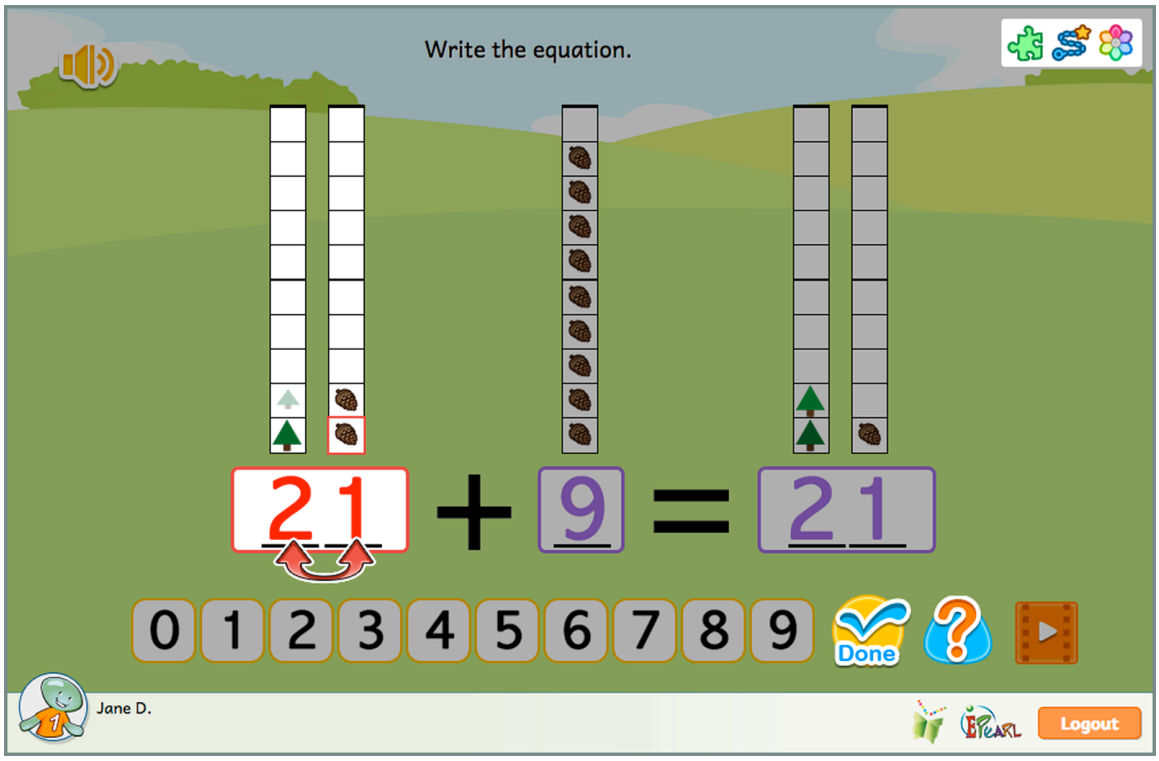


Figure 80: Place Value Step 8, Phase 2 - Incorrect Feedback Example of Switching the Tens and Ones Place

Step 9

This step has the student subtract a one-digit number from a two-digit number. The student does so by removing pinecones from the two-digit number's counter. If they do not see enough pinecones in the ones counter, then they will have to convert a tree into a pinecone counter (i.e. borrow). Once they have subtracted the number asked for, they are asked to represent this process by writing the equation. Half the time, the student will be asked to write the equation a - b = c and the other half of the time, it will be presented as c = a - b.

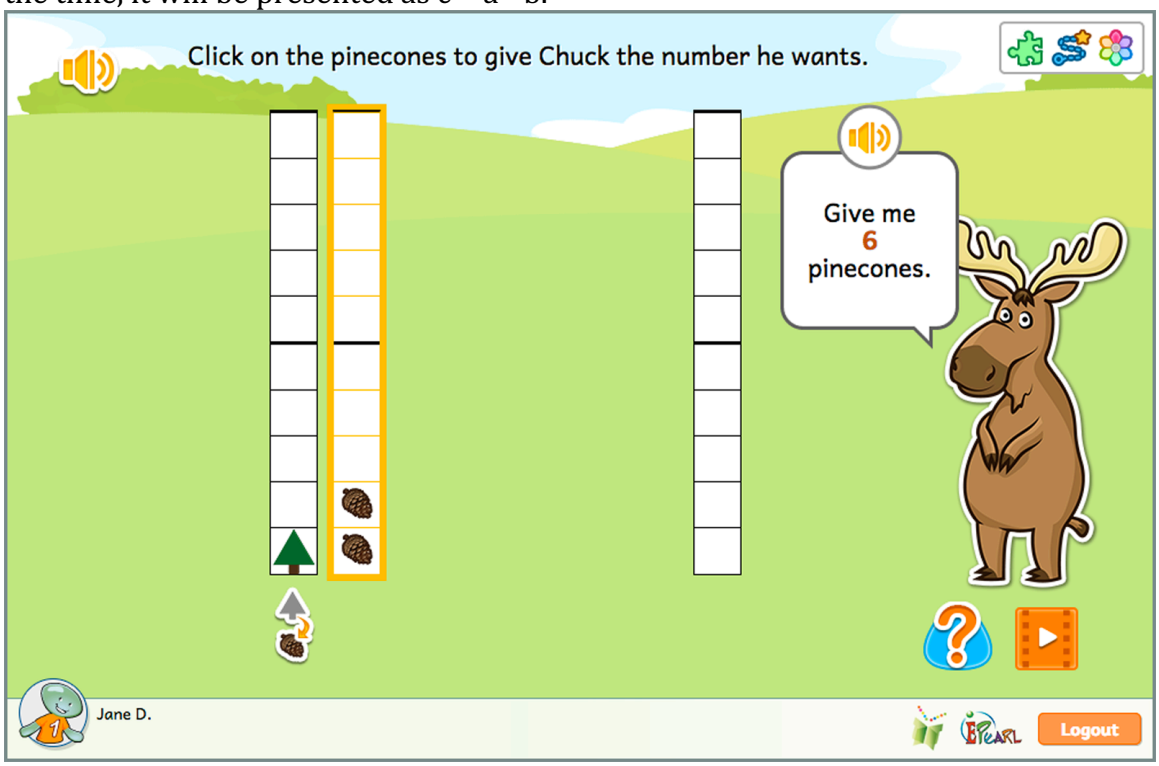


Figure 81: Place Value Step 9, Phase 1

Incorrect Feedback

There are several different types of errors a student can make in the first phase. If the user did not move the requested number of the pinecones, the pinecones in Chuck's counter will be highlighted with the numeral appearing next to it. The student can compare this number to what appears in Chuck's bubble. If the student needs to convert a tree into a counter with ten pinecones in order to provide Chuck the amount he asked for, the tool will play a brief animation showing that process before it reverts back to the student's answer. If the student unnecessarily transformed a tree (i.e. borrowed 10), the tool will play a brief animation showing the process of converting a full pinecone counter into a tree before reverting back to the student's answer. If the student made multiple errors then the feedback for each type is shown sequentially.

If the student made an error during the second phase, ELM will use the counters to help students see the mistake. If the digit the student entered is less than the

trees/pinecones in the counter, then the cells surrounding up to that number are surrounded. The student can then compare their answer to where the trees and pinecones appear. If the student entered a digit larger than the trees/pinecones in the counter, then additional transparent trees/pinecones appear in the counter to indicate what the student's answer would look like. If the student mixed up the tens place and the ones place, a double-sided arrow will appear below the digits as well. If the student made multiple errors then the feedback is shown sequentially from left to right, focusing on one number at a time.

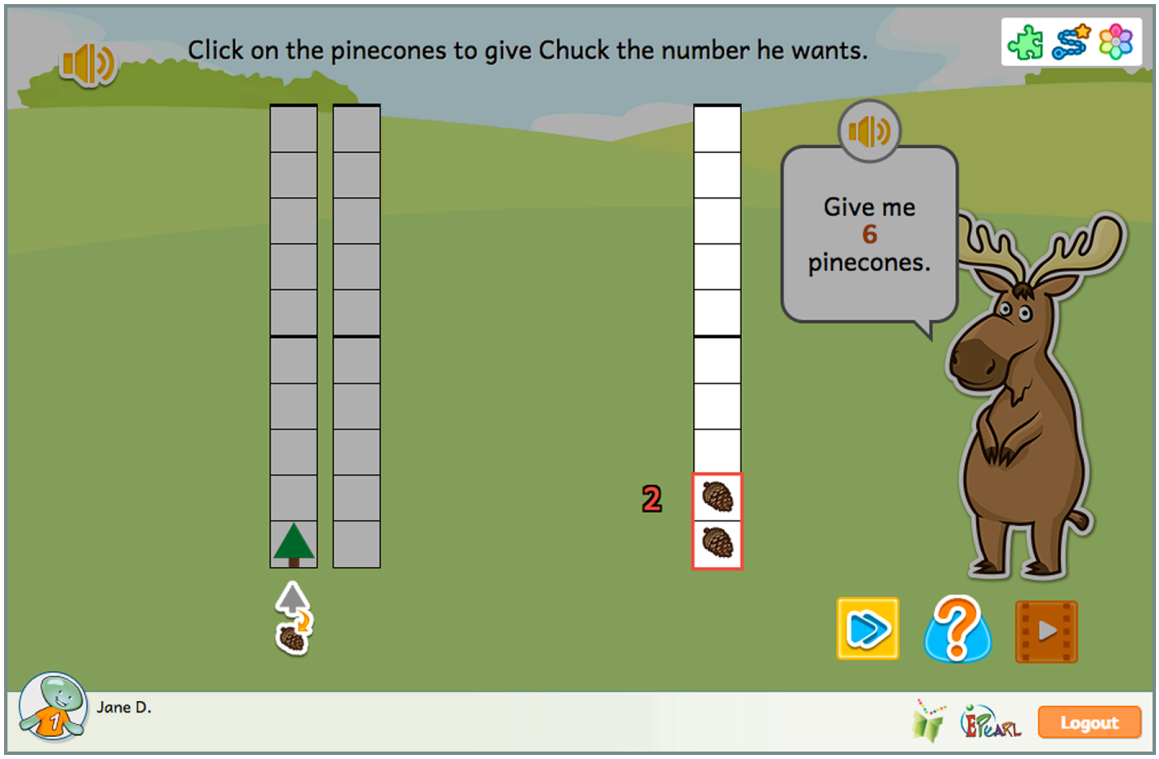


Figure 82: Place Value Step 9, Phase 1 - Incorrect Feedback Example of Not Subtracting Enough

Geometry

This theme asks students to categorize and distinguish two-dimensional shapes. ELM's goal is to develop students' fluency in recognizing shapes and foster students' own criteria for correctly identifying shapes. To this end, ELM does not list a shape's attributes. Instead, the student is provided with varying prototypes and they must define their own criteria for what makes a shape a shape. Teachers can have students justify their definitions of shapes during consultations to ensure adequate and robust understanding has unfolded.

Identify Shapes

This Idea aims to lead students to realize that there is a set of properties or characteristics that determine if something is a member of a class of shapes. While ELM does not state any explicit guidelines, students are guided into developing their own understanding that all shapes are closed figures. Furthermore, the boundaries of all shapes considered are composed solely of straight lines, other than for a circle, where the boundary is a curved line. Varied prototypes may help students note that the number of vertices is a characteristic used in defining classes of shapes. As the steps increase in complexity, students will also note that size is not a property that determines the class of a shape.

Step 1

ELM presents the student with an array of two-dimensional shapes and open figures. The host, Tia, asks students to sort the objects into one of two boxes. Tia will ask for a certain shape in the box closest to her, and all other objects ought to be sorted into the other box. By having students sort all of the objects, they make a conscious decision about which of these objects qualify as the requested shape. ELM asks students to identify circles, squares, rhombi, rectangles, and triangles – in that order the first time they encounter the steps. This order follows the level of difficulty students typically have with identifying shapes. The objects that are not the requested shape consists of incomplete figures, over-extended figures, and shapes of other classes that are similar to the requested shape. In this step, all objects are roughly the same size.

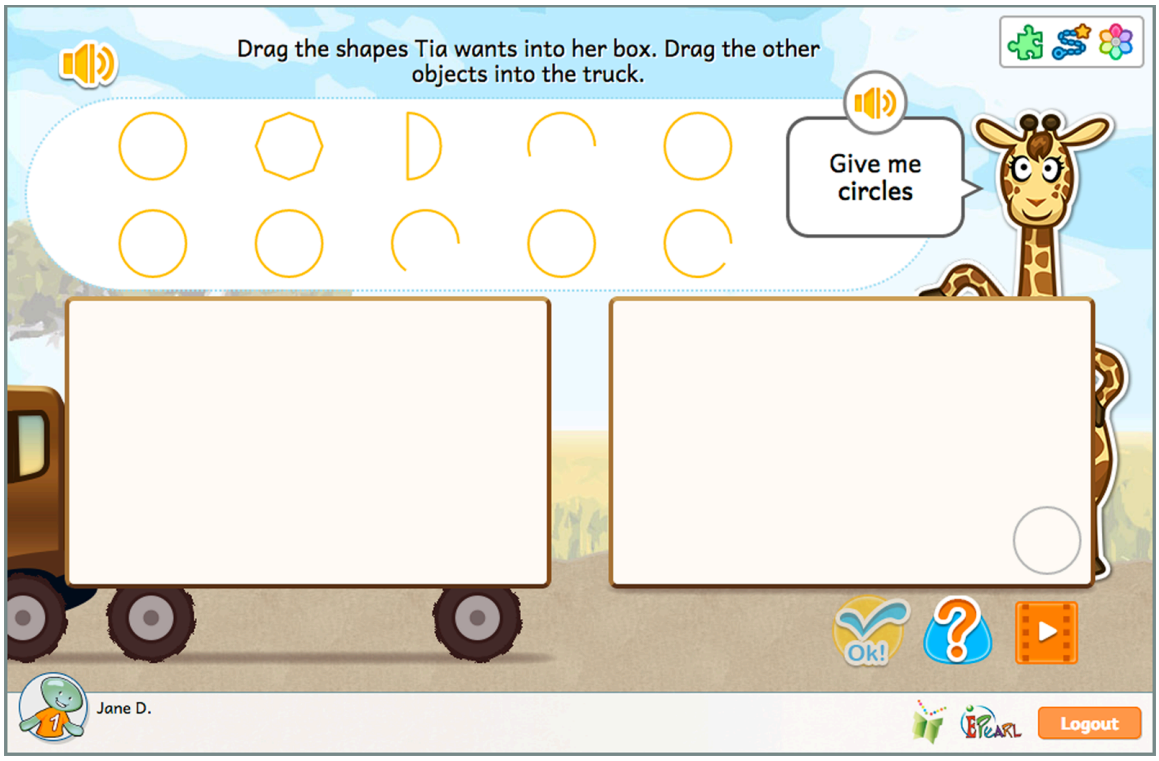


Figure 83: Identify Shapes Step 1

Incorrect Feedback

There are a number of ways the student can incorrectly sort the objects. In all cases, the prototypes in Tia's box get filled in to make them stand out more. If they place an over extended figure in Tia's box, the overextended portions become highlighted. If they place an incomplete figure in Tia's box then that figure is highlighted so students may more easily compare it to the prototypes. If the student placed a different shape than the one asked for in Tia's box then that shape is highlighted and Tia prompts the student to consider how this shape is different from the prototypes. If the student placed the asked for shape in the wrong box then that shape is highlighted so students may more easily compare it to the prototypes. If the student made multiple types of errors then the feedback is shown sequentially.

Figure 84: Identify Shapes Step 1 - Incorrect Feedback Example of Incomplete Figures

Step 2

Building on the previous step, the student is once again asked to sort objects, with Tia asking for a particular shape. Tia will once again ask for either circles, squares, rhombi, rectangles, or triangles. The objects that are not the requested shape consists of incomplete figures, over-extended figures, shapes with a curved side, and shapes of other classes that are similar to the requested shape. This step has more alternative shapes than the previous step. In addition, all objects are varying sizes.

Figure 85: Identify Shapes Step 2

Incorrect Feedback

There are a number of ways the student can incorrectly sort the objects. In all cases, the prototypes in Tia's box get filled in to make them stand out more. If they place an over extended figure in Tia's box, the overextended portions become highlighted. If they place an incomplete figure in Tia's box then that figure is highlighted so students may more easily compare it to the prototypes. If they place a shape with one or more curved sides, any curved side becomes a dotted line. If the student placed a different shape than the one asked for in Tia's box then that shape is highlighted and Tia prompts the student to consider how this shape is different from the prototypes. If the student placed the asked for shape in the wrong box then that shape is highlighted so students may more easily compare it to the prototypes. If the student made multiple types of errors then the feedback is shown sequentially.

Figure 86: Identify Shapes Step 2 - Incorrect Feedback Example of Shapes with Curved Lines

Step 3

Further building on the previous two steps, the student is once again asked to sort objects, with Tia asking for a particular shape. However, some of the objects will be rotated, increasing the difficulty. Because the focus is on rotation, Tia will no longer ask them to sort circles. The not asked for shapes will consist of other two-dimensional shapes that look similar to the requested shape.

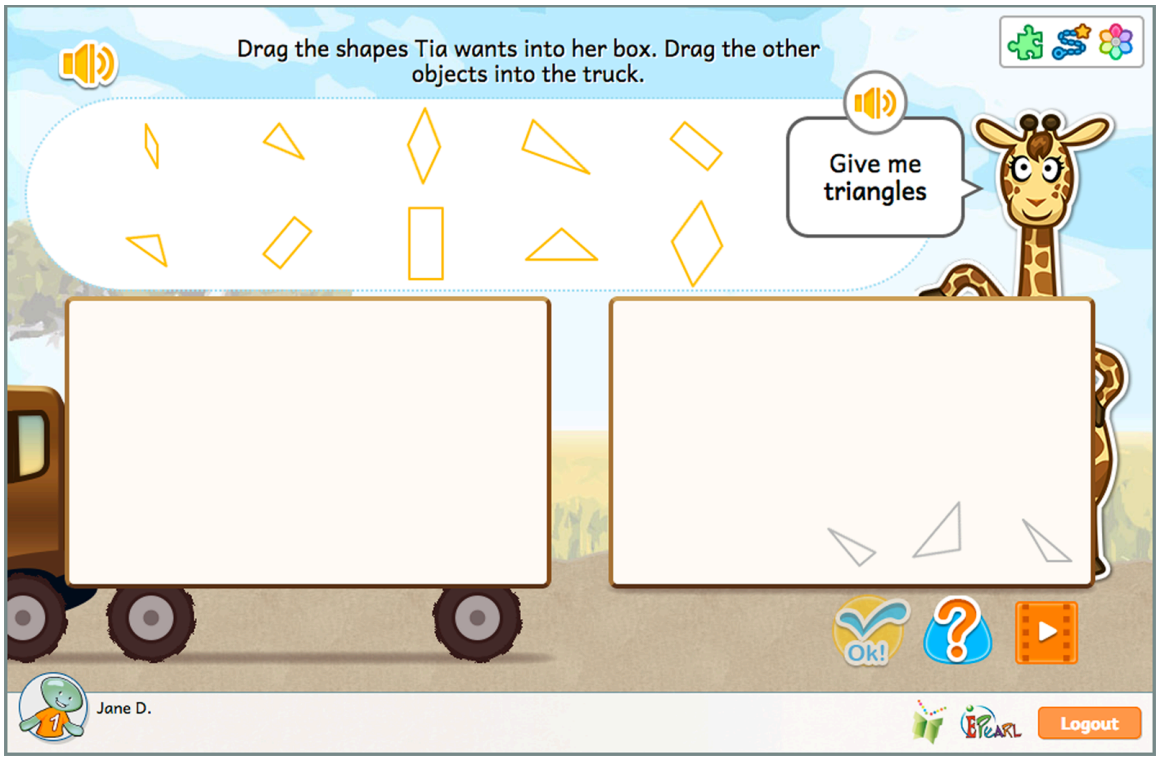


Figure 87: Identify Shapes Step 3

Incorrect Feedback

The student can make two kinds of error: they gave Tia a two-dimensional shape she did not ask for or they sorted the asked for shape into the truck. If the student placed a different shape than the one asked for in Tia's box then that shape is highlighted and Tia prompts the student to consider how this shape is different from the prototypes. If the student placed the asked for shape in the wrong box then that shape is highlighted so students may more easily compare it to the prototypes. If the shape has a non-standard orientation, then there will be a sort animation where that shape is rotated until its orientation is more familiar to what the student is used to seeing. It will revert back to its original rotation when students attempt to correct their errors. If the student made multiple types of errors then the feedback is shown sequentially.

Figure 88: Identify Shapes Step 3 - Incorrect Feedback Example

Patterns

In early primary grades, students are expected to develop their skills in recognizing the changing attributes in patterns, especially determining the rule for a repeating pattern. Students typically express their understanding by recognizing, continuing, completing and creating patterns. ELM aids the development of their skills in identifying regularity and building sequences.

Translate Patterns

This idea is recommended as a continuation following the development of basic pattern copying, completion and continuation skills.

There are two main objectives for this Idea. The first is developing students' ability to identify the repeating portion – the core, or unit of repeat. The student is asked to extend this understanding of the core structure in the second objective, which is abstracting the pattern. Students demonstrate this by recreating the pattern using a new set of objects. The objects in the initial pattern, as well as the ones provided to the student to create a new sequence, will vary for each repetition of the step.

Step 1

The student is presented with objects arranged in a pattern. There is a minimum of 4 objects (2 objects x 2 units of repeat) and a maximum of 12 objects (4 objects x 3 units of repeat). The student's first task is to identify the pattern core. If they are able to correctly identify it, they are then asked to recreate that core using different objects. Once the student has correctly imitated the pattern core, they are asked to repeat it to match the initial pattern presented.

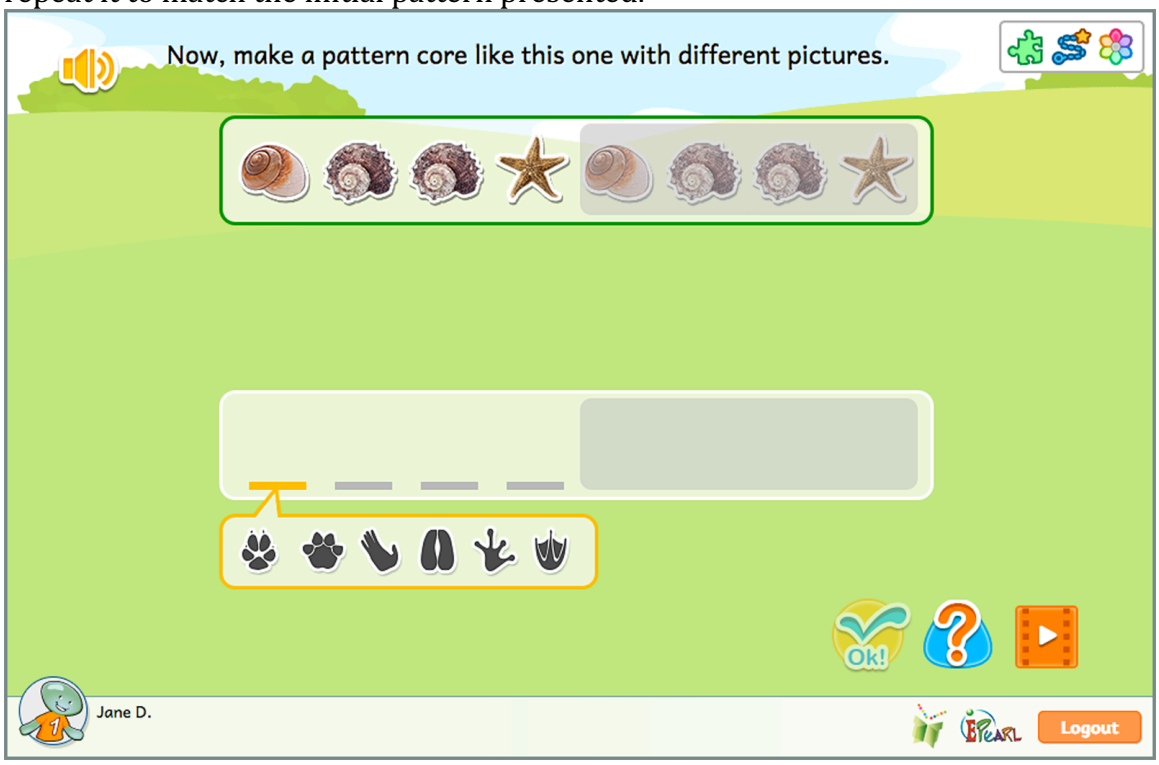


Figure 89: Translate Patterns Step 1, Phase 2

Incorrect Feedback

During the first phase, the first time the student makes an error there will be some audio feedback that guides students to select the images that make up one group. There is a brief animation that separates the pattern core before they revert back to an evenly distributed line of objects. If the student makes another error, ELM will provide letter symbols (ABCD) to express the pattern. There is audio guidance to suggest that the student start with the first object that is repeated. If the student makes a third error, ELM will show them the pattern core before resetting the activity so that they can try with a new set of objects.

When the student is asked to recreate the pattern core in the second phase, if the student makes an error, ELM will provide letter symbols (ABCD) for both patterns. The student can then compare their answer to the pattern above.
Errors with imitating the pattern core in the final phase will take the original core pattern the student created and move it above each of the erroneous cores. The student can then compare their pattern to the original pattern core they created.

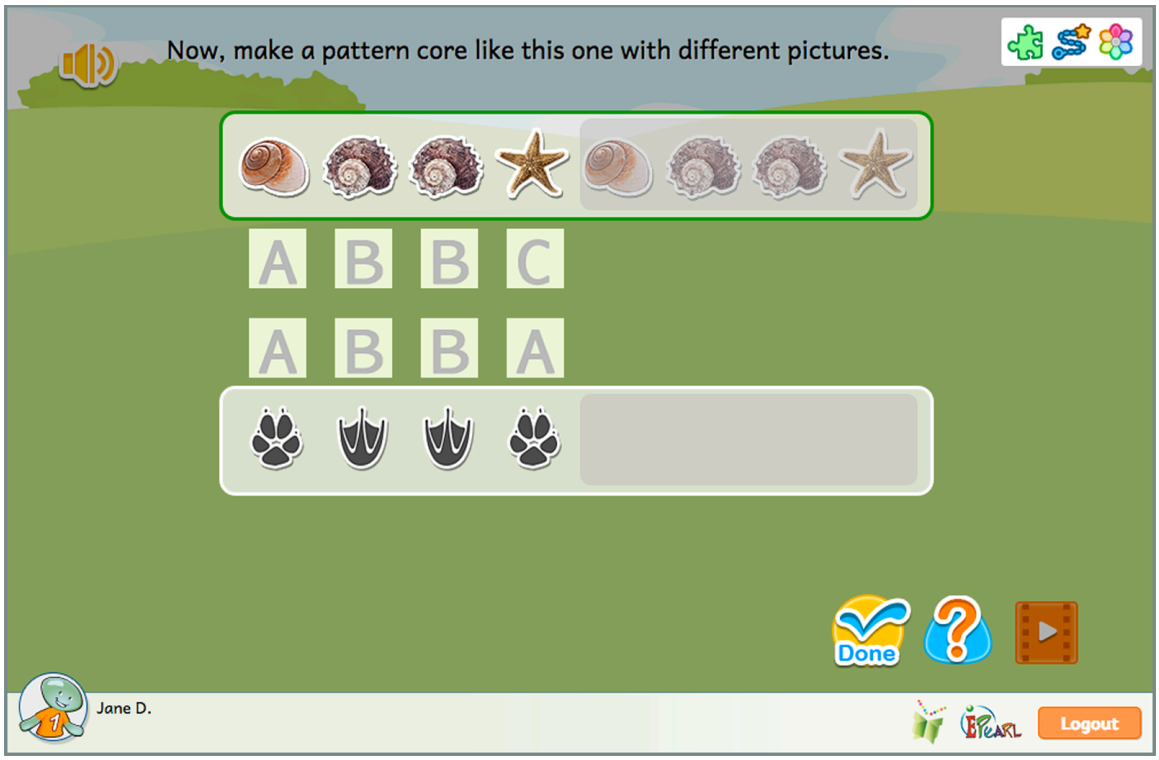


Figure 90: Translate Patterns Step 1, Phase 2 – Incorrect Feedback Example

Data

In grade 1, students are expected to pose or respond to questions, organize data, and interpret data using graphs and tables, with their teacher's guidance. To support students' development of these skills, this theme presents situations where the answer is not instantly obvious. In order to make sense of the situation, the student is required to organize data according to common attributes and represent a tally using graphs and tables. This task connects the situation to the graphic displays.

Bar Graphs/Tables

The purpose of this Idea is support students' ability to interpret and display data using bar graphs and tables. The student is provided with a context and they are expected to count and represent that tally using pictures, counters and numerals. The situation that the data is provided in offers a context for the bar graph and table to be meaningful. The student discovers that a bar graph is useful for organizing data into categories to determine the relative sizes at a glance. A table can be useful to quickly count the total.

Teacher Tip: Encourage students to go beyond just reading the data. Ask them to use the tables in ELM to compare quantities (most, least).

Step 1

The student is given a random situation between being shown the hosts' collection of X, their friends' favorite Y, or Z type of objects the host noticed that day. Along with this situation, the student is presented with a pile of objects. This pile consists of 2-4 categories and a total of 10-15 objects. The student's first task is to identify the categories in the pile of objects. Then they are expected to label a bar graph so that each category is represented. The student is then prompted to complete the bar graph in relation to the given pile of objects.

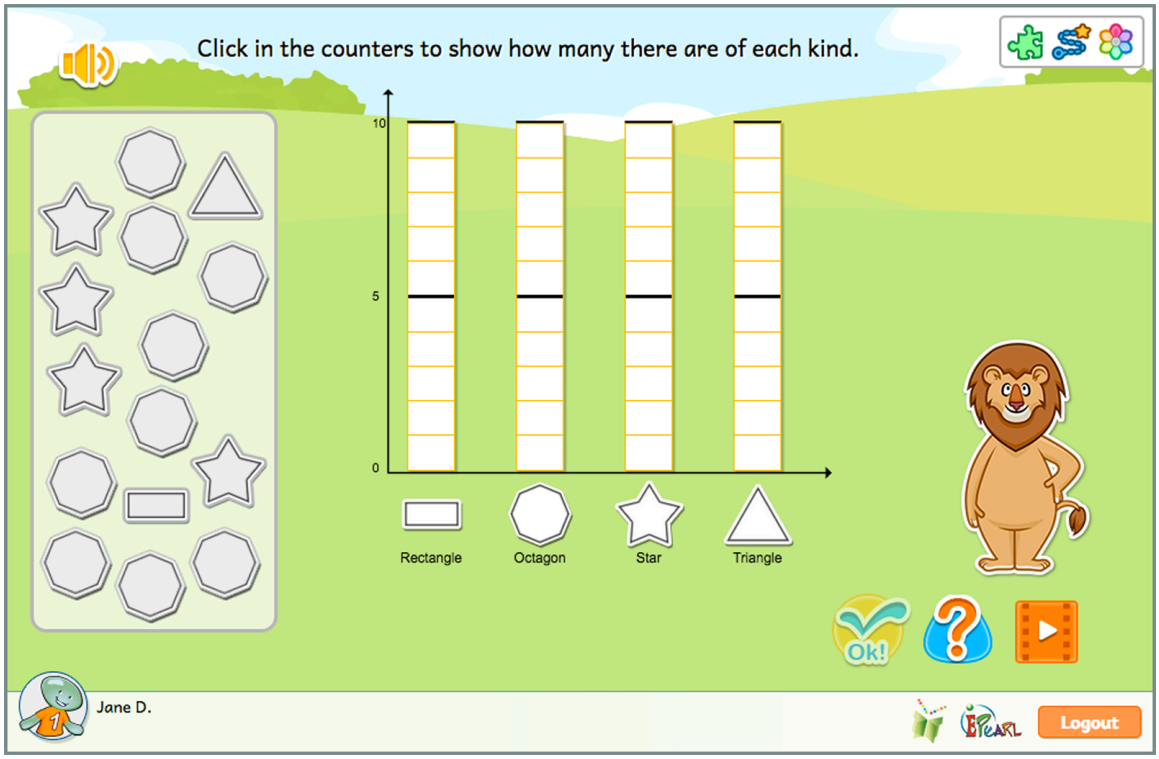


Figure 91: Bar Graphs and Tables Step 1, Phase 3

Incorrect Feedback

If the student makes an error in the first phase, by selecting multiple objects in the same category, then the tool will highlight one of the objects in cyan and all of the extra objects in red and state that only one of each kind is needed. If the student did not select one of the categories then all objects in that category are highlighted in red and Kiros will let them know that they overlooked one or multiple categories. If the student made multiple types of errors then the feedback is shown sequentially.

It is not possible for the student to make an error labeling the graph in the second phase, as the OK button is not active until all labels have been created.

In the third phase, the student is asked to fill in the counters in the bar graph. They can make an error by not correctly counting the objects in a category. In this case, the objects on the left will be highlighted in red as well as the counter. The student is

expected to compare the objects and the counter's cells. If the student made multiple errors in different categories, the feedback is shown sequentially.

If the student enters an incorrect numeral in the table during the fourth phase, the counter in the bar graph as well as the incorrect number in the table are highlighted in red. If the student made multiple errors in different categories, the feedback is shown sequentially.

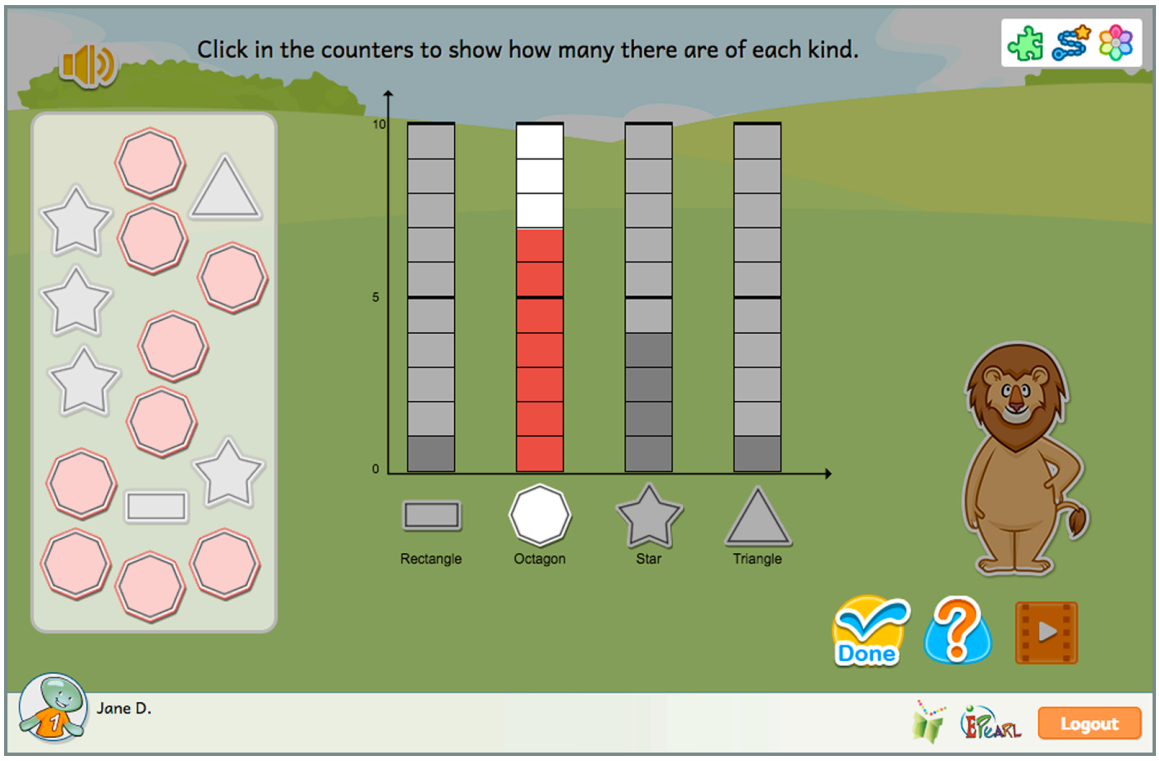


Figure 92: Bar Graphs and Tables Step 1, Phase 3 - Incorrect Feedback Example

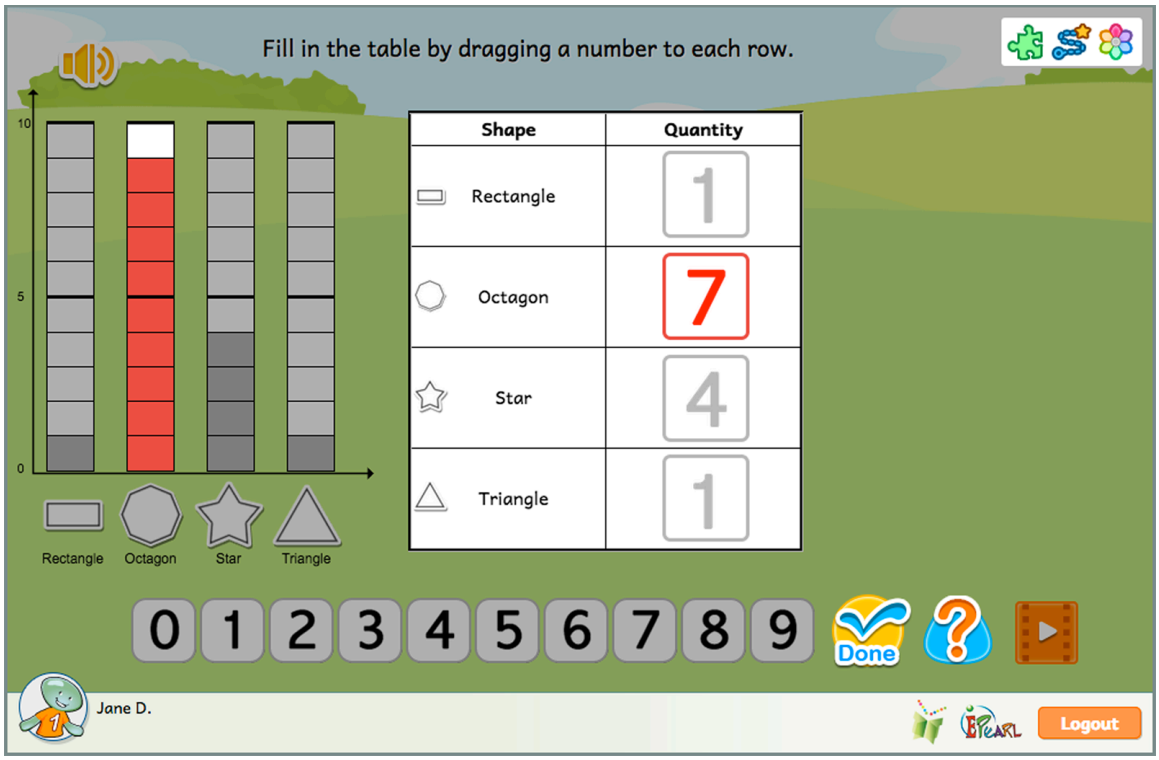


Figure 93: Bar Graphs and Tables Step 1, Phase 4 - Incorrect Feedback Example

Step 2

This step is the same as the previous one but also asks students to complete the table at the end. The student is randomly given one the situations seen in the previous step. They must identify the categories, label a bar graph, and then fill in the bar graph. Once they have successfully completed the bar graph, the student is asked to fill in a table using the information in their bar graph. This demonstrates that both the bar graph and table can be used to represent their data.

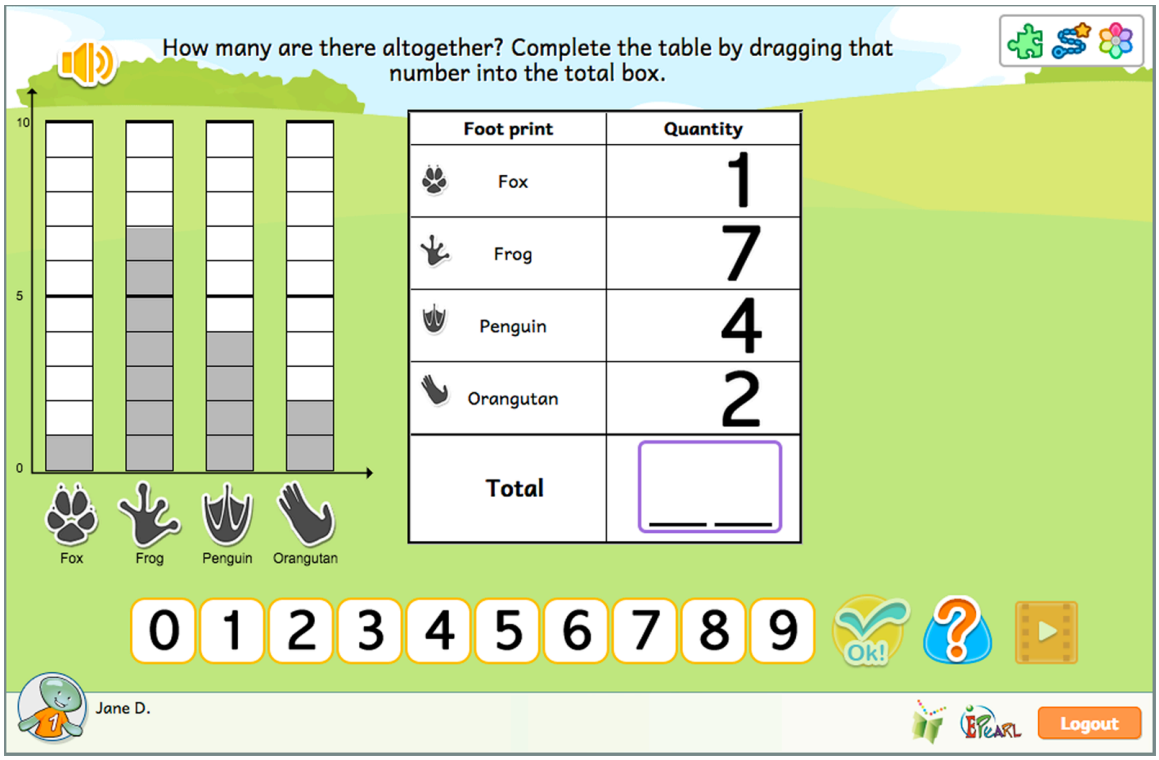


Figure 94: Bar Graphs and Tables Step 2, Phase 5

Incorrect Feedback

The initial phases have the same feedback as Step 1. If the student makes an error in the first phase, by selecting multiple objects in the same category, then the tool will highlight one of the objects in cyan and all of the extra objects in red and state that only one of each kind is needed. If the student did not select one of the categories then all objects in that category are highlighted in red and Kiros will let them know that they overlooked one or multiple categories. If the student made multiple types of errors then the feedback is shown sequentially.

It is not possible for the student to make an error labeling the graph in the second phase, as the OK button is not active until all labels have been created.

In the third phase, the student is asked to fill in the counters in the bar graph. They can make an error by not correctly counting the objects in a category. In this case, the objects on the left will be highlighted in red as well as the counter. The student is expected to compare the objects and the counter's cells. If the student made multiple errors in different categories, the feedback is shown sequentially.

If the student enters an incorrect numeral in the table during the fourth phase, the counter in the bar graph as well as the incorrect number in the table are highlighted in red. If the student made multiple errors in different categories, the feedback is shown sequentially.

If the student provides an incorrect total in the fifth phase, the number in each row temporarily gets bigger and a plus sign appears in the last row. In addition, a smaller pile of the objects appears to the right of the table to help student visualize what each number looks like.

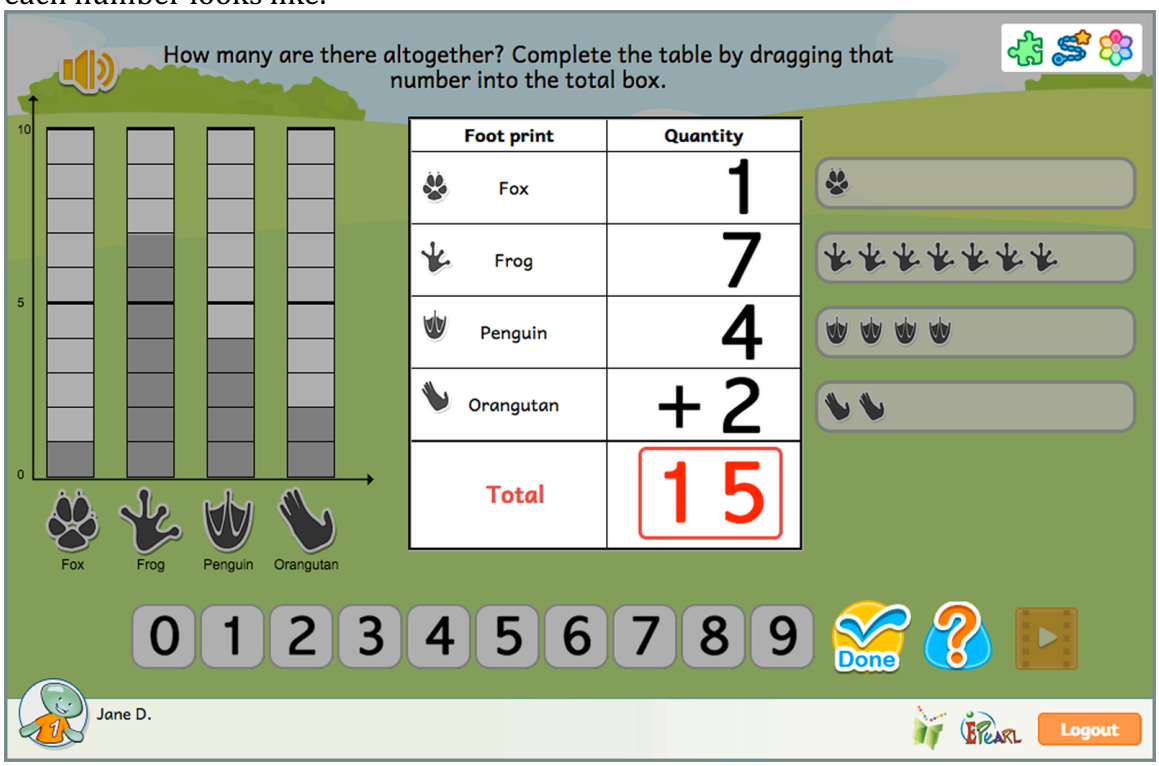


Figure 95: Bar Graphs and Tables Step 2, Phase 5 - Incorrect Feedback Example

Number Line

Number lines provide a second understanding of the concept of numbers explored earlier in the *Number Concept* theme. Focusing on the position on a line offers another concrete method for students to count, compare, and order numbers. The number line helps students to see that counting numbers are ordered, with counting up related to increases in quantity and counting down related to decreases in quantity. Positive and negative displacements indicate movement in opposite directions along a number line, allowing students a new interpretation of addition and subtraction. The use of a standard size of units (step length) also encourages students to discuss the use of different systems of "units," e.g. mm, cm, m, inch, foot, yard, which lead to different correct numerical answers.

Number as Displacement

This Idea provides students with a situational problem where three numbers are related. The starting point (a), the displacement (b), and the ending point (c) are presented by the equation "a + b = c" or "a – b = c". Two out of these three are provided. The student's first task is to determine what each given number

corresponds to physically on the number line. The student can use the physical interpretation to aid in determining the missing third value. In the process of using the number line, students may count/add by 1s, 5s, and 10s and proficiency in composing/decomposing numbers while gaining fluency in addition/subtraction with numbers up to 100.

Note: This Idea should not be the first instance that students are introduced to a number line. Rather, ELM suggests a kinaesthetic approach to start. See the Teacher Resources page for suggested offline lessons before directing students to the online idea.

Step 1

The student is shown a number line from 0-100. The host, Matilda, will provide a situational word problem that describes the starting point (a), the displacement (b), and the ending point (c). One of the values will be missing so the student will be provided with either the start position and displacement, the end position and displacement or the start and end positions. They are tasked with determining the missing value. The student starts by placing the starting or the ending position on the number line. They do so by dragging the number from the word problem or equation. If they get this correct, they are then tasked with creating the displacement by adding 1, 5 or 10 unit blocks. These represent the steps Matilda has taken along the number line. Once the student has correctly built the displacement (length and direction), the missing value is provided.

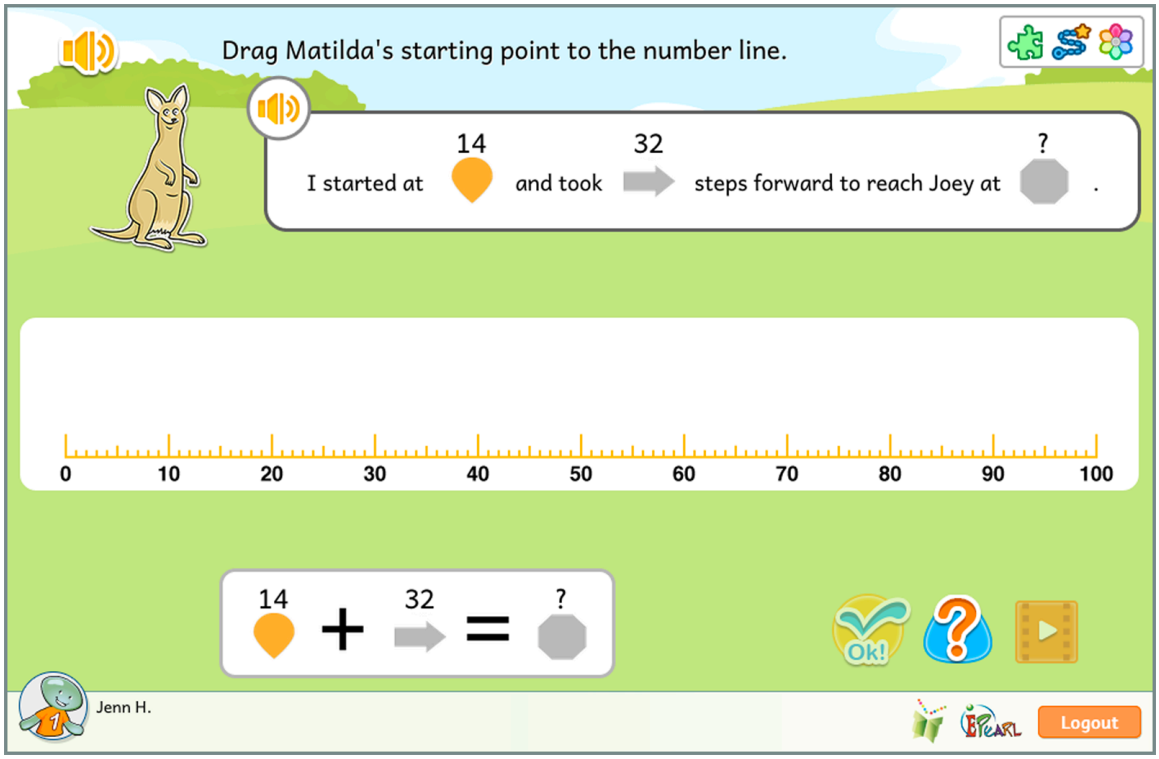


Figure 96: Number as Displacement Step 1

Incorrect Feedback

In the first phase, if students place the starting or ending point on the incorrect notch, the marker will turn red and the value will be displayed in a red font. The starting or ending value in the word problem and equation will also turn red. This will allow the student to compare their answer on the number line to the value in the word problem/equation. For situations where the student was provided with the starting and ending point and they put the starting marker on the ending value in the number line or vice versa, the shape of the markers will also be emphasized.

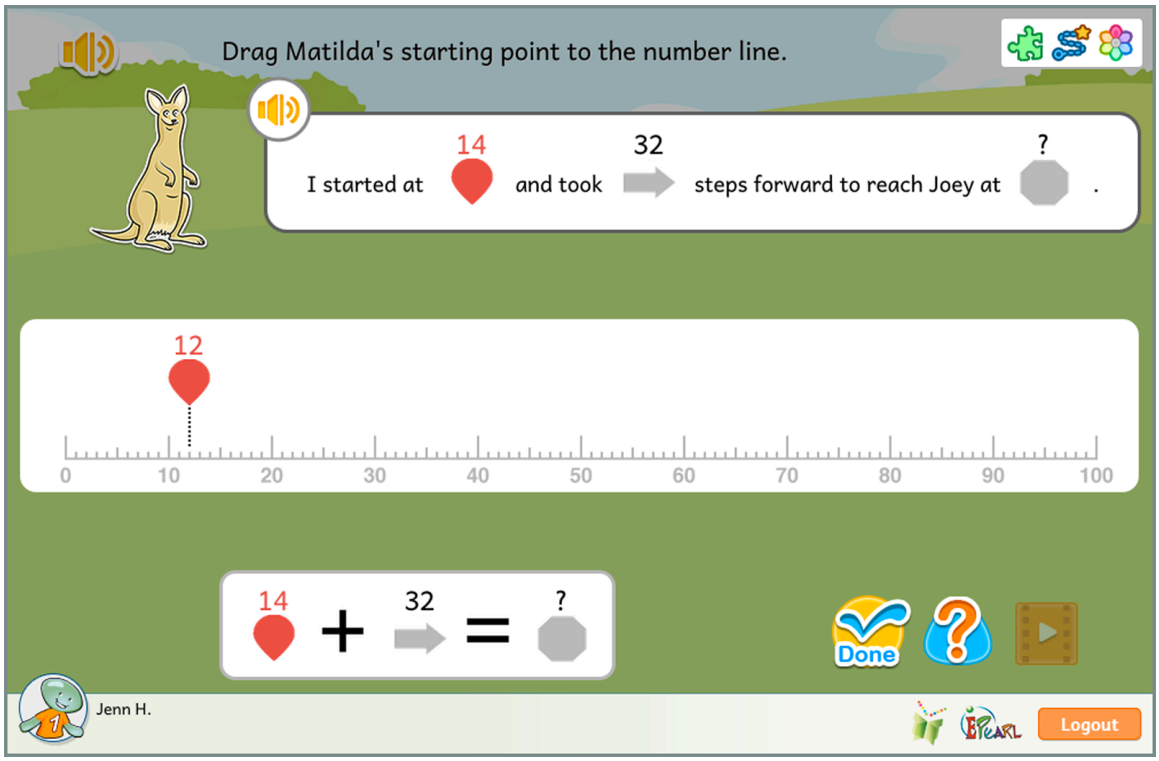


Figure 97: Number as Displacement Step 1, Phase 1 - Incorrect Feedback Example

There are two kinds of errors the student can make when creating the displacement in the second phase: direction and/or length. When the student is provided the displacement and either the start or end position and they create the displacement in the opposite direction then one of the blocks will gain an arrowhead pointed towards the ending position. The word forward/backward in the word problem is highlighted as well as the outline for the displacement arrow. The student can compare the two. If the student makes an error in the length of the displacement then the blocks will combine and the total value will be displayed. The displacement value in the word problem and equation turn red so the student can compare the two values. If the student makes an error in both direction and length, the feedback will be shown sequentially. For situations where the student is given the start and

end positions the incorrect feedback will be the same no matter if the error is one of direction, length or both. Rather, the dotted line touching the edge of the displacement is emphasized and the number appears above the number line. The not-placed start or end position in the word problem/equation becomes red so the student can compare the two values.

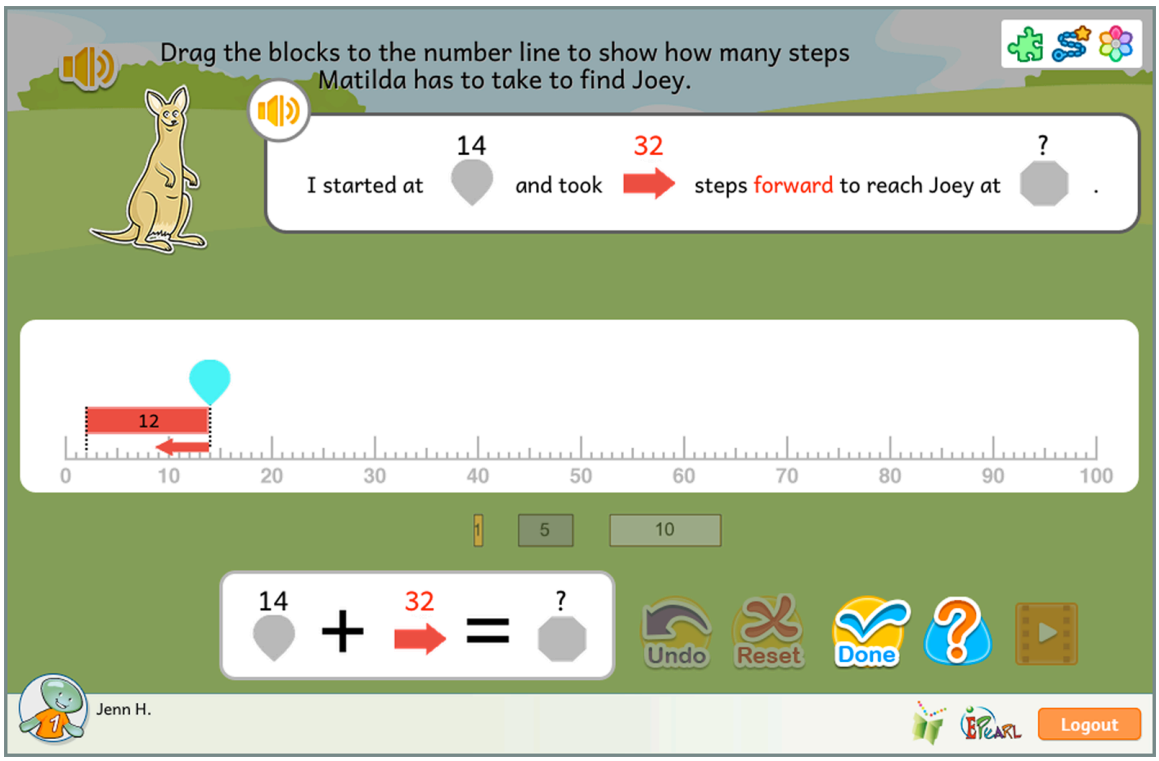


Figure 98: Number as Displacement, Step 1, Phase 2 – Incorrect Feedback Example

Teacher Module

The Teacher Module is designed to support teachers' use of ELM. There are two components to this module: a *Teacher Resource* page and the *Teacher Manage* feature. Teachers can utilize the resource page to learn more about the tool and access classroom resources such as lesson plans. The *Manage* feature allows teachers to follow and modify students' progress.

Teacher Resource Page

The *Teacher Resources* web page provides a complete list of resources that have been prepared by the ELM team with input from teachers. To access the site, go directly to the URL: http://grover.concordia.ca/resources/elm/teacher/en/. Alternatively, from within the tool this page can be accessed on the Lobby Page by clicking on the apple icon  .

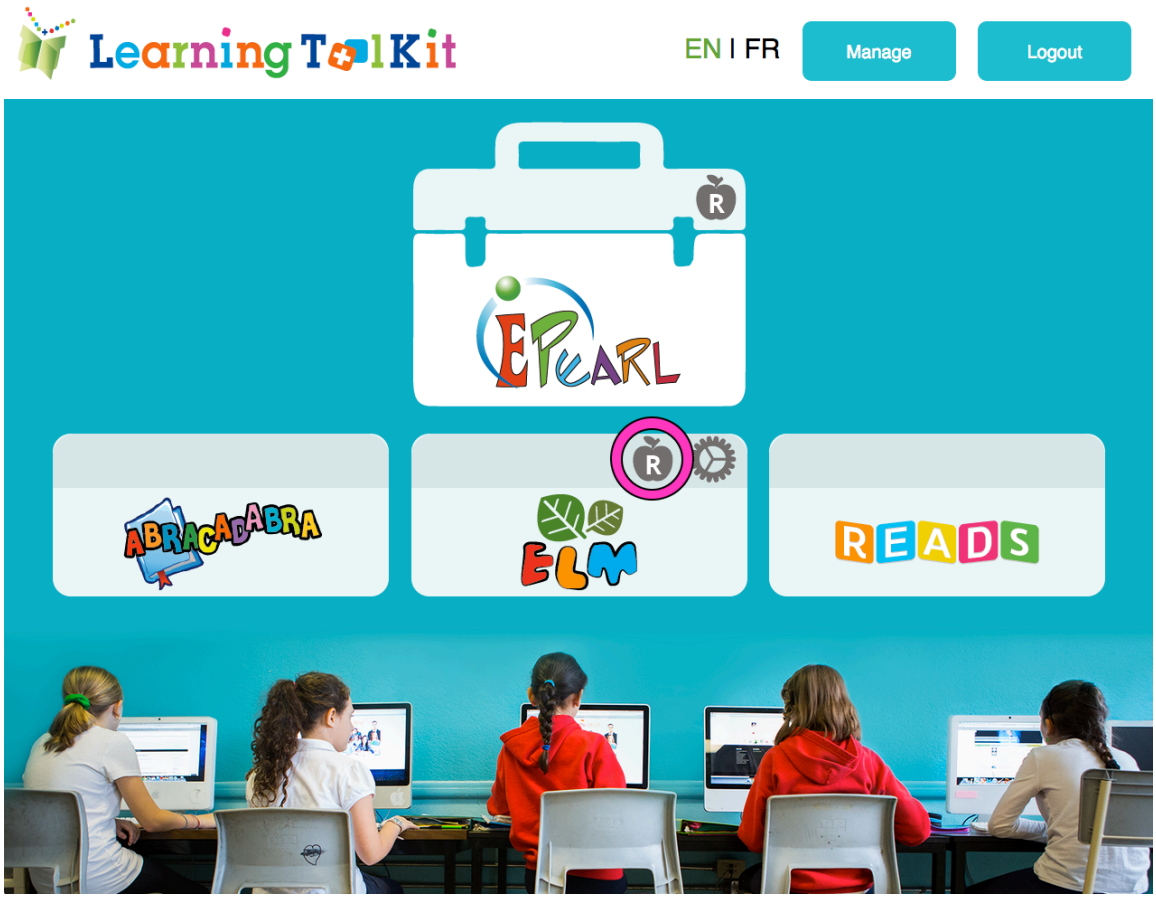


Figure 99: The LTK+ Lobby Page, Teacher Resources icon

Figure 100: The Teacher Resource Page

Lesson Plans

ELM provides suggested lesson plans for our online activities as well as for additional themes not covered within the tool.

Consolidation Questions

Each of the lesson plans found on the *Teacher Resources* page contains a section of consolidation questions. The questions are specific to the step and are intended to guide classroom discussions. They serve as a suggested way to discuss the mathematical concepts and ensure students reflect and synthesize their understanding.

Offline Lessons

In addition to the online activities, ELM has four offline lesson plans. Two of these support learning related to *Number Line*, while the other two introduce the idea of *Mathematical Language*.

Teacher Manage Feature

The *Teacher Manage* feature enables teachers to get notifications about which students are struggling with the steps, see how their students are progressing through the tool, create custom plans, and assign extra animal friends.

This feature can be accessed from the Lobby Page by clicking on the cog icon .

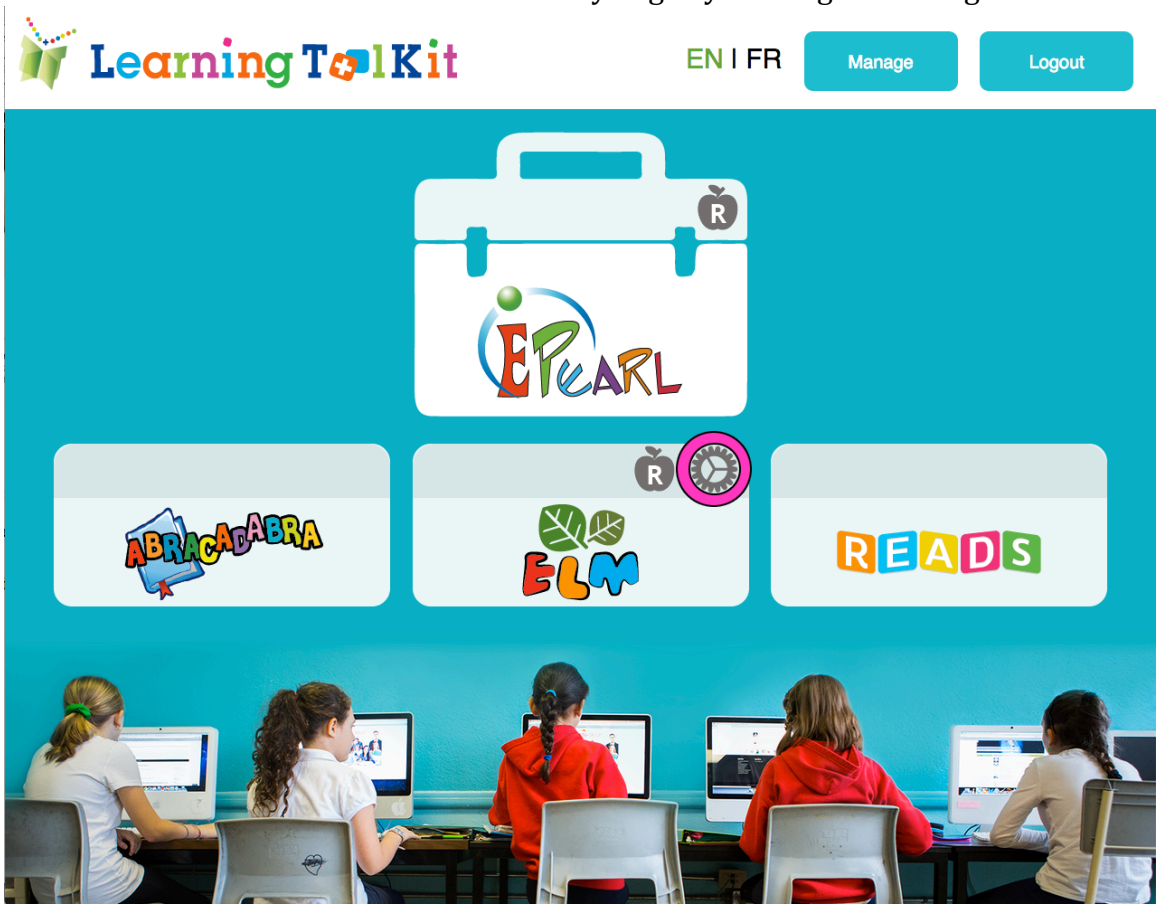


Figure 101: The LTK+ Lobby Page, Teacher Manage icon

Notifications

The first feature that is seen when accessing the *ELM Settings* are the notifications.

Recall how the soft-lock feature functions: if the student makes three errors in a row, they will be given a new problem to solve. If they continue to make three more errors in a row, they are advised to seek help from their teacher. ELM will notify the teacher so they are aware of any challenges students encounter. Although this icon  appears on the student's screen to indicate they need help, a teacher may not be able to address all errors and difficulties in the classroom. The *Notifications* tab keeps a running tally of students consistently struggling with a particular step.

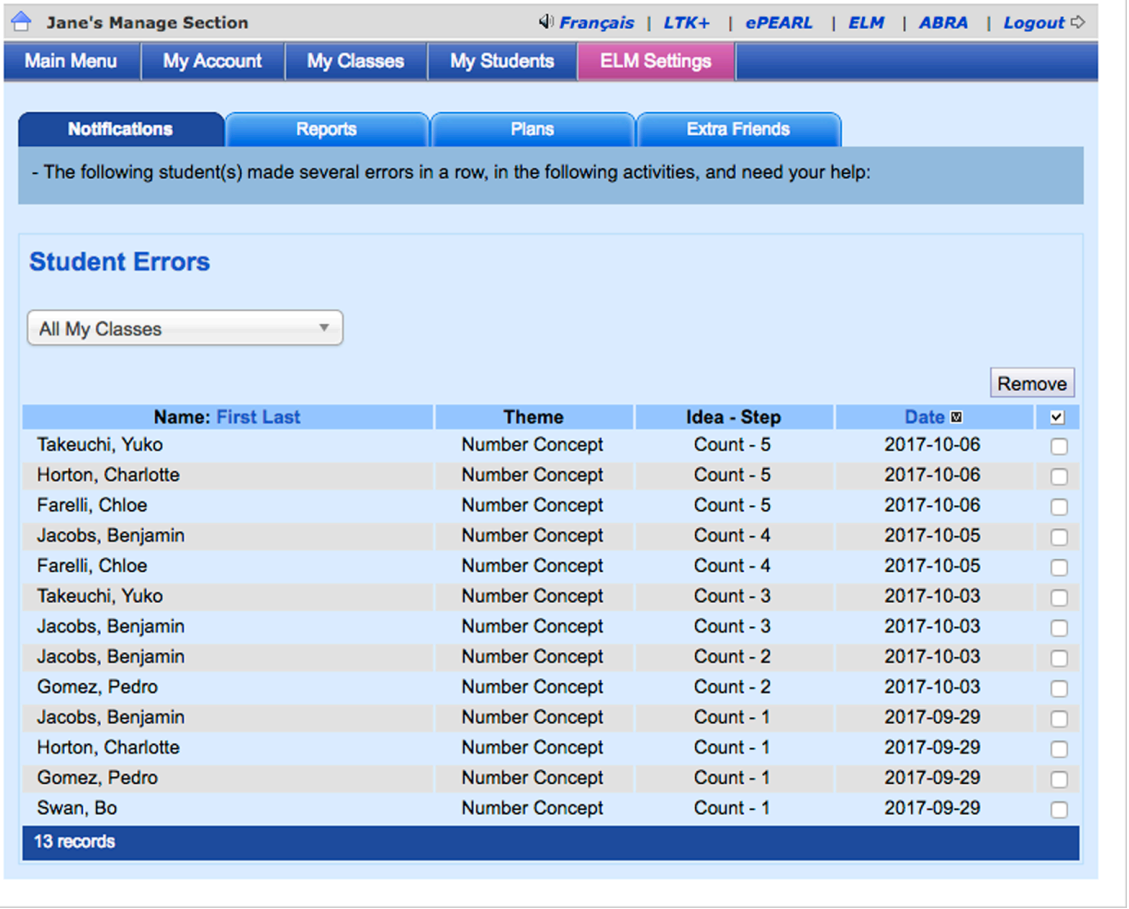


Figure 102: Teacher Manage, Notifications Tab

Each notification consists of the student's name, the Theme, Idea and Step, and on what date. A teacher can sort this list by student name or by date. To remove the notification, check the box and click "Remove". This will only remove the notification from this list, not the record of the mistake. So, if they are still stuck that will be reflected in the report as well as in their account.

Reports

The *Report* tab shows students' progress through ELM activities and any difficulties they are experiencing.

A teacher will be asked to select a class before s/he can see the reports.

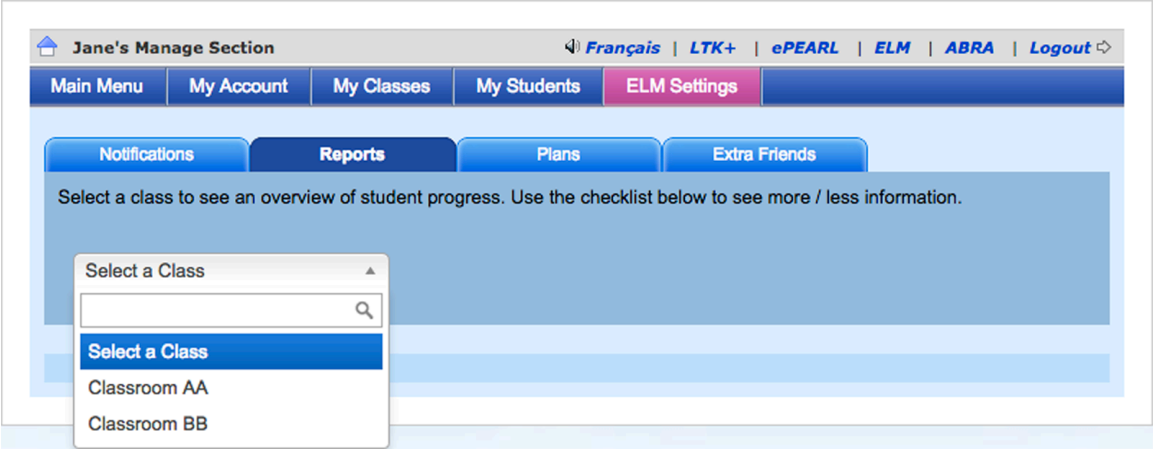


Figure 103: Teacher Manage, Reports Tab

A teacher can then determine which Theme and Idea s/he want information about:

By default, *Number Concept* and *Count* will be pre-selected. Use the dropdown menus to select other Themes and Ideas.

A checklist and report will load below. The checklist can be used to narrow or broaden how much information is shown in the report.

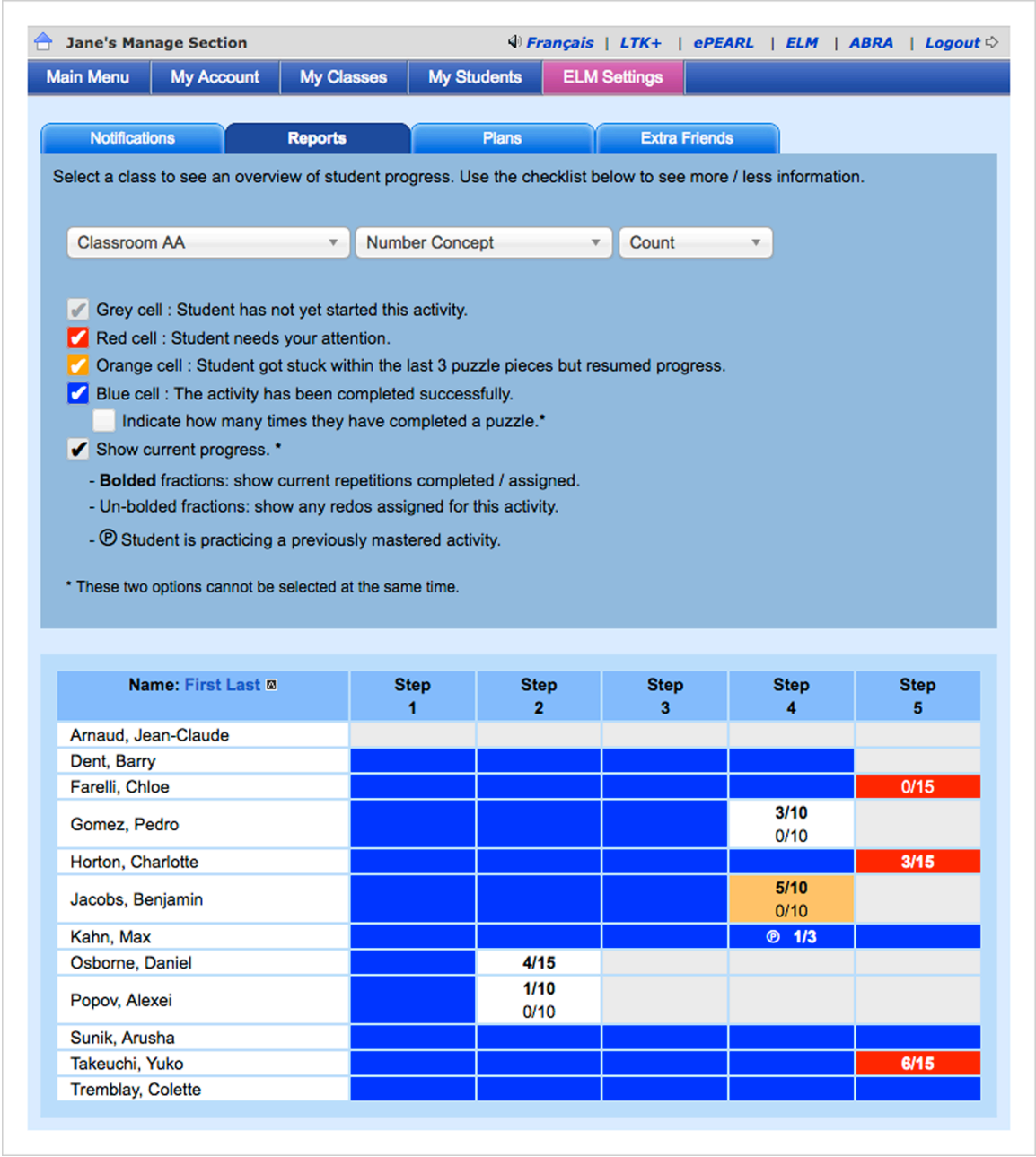


Figure 104: Teacher Manage, Reports Tab - Sample Report

A grey cell indicates that the step has not been started yet. This is selected by default and cannot be unchecked.

A red cell shows that the student is currently experiencing difficulties with a particular step and is unable to continue. This information would have also been provided in the *Notifications* tab. It is selected by default but a teacher can uncheck this option.

The orange cells mean the student had been stuck on that step recently but has been able to make some progress. This marker will disappear once they have successfully completed three puzzle pieces in a row or finish the puzzle.

A blue cell indicates that the step has been completed. If a teacher has assigned a plan where the student has to complete the puzzle twice, then the cell will not turn blue until both puzzles have been completed.

Once a student has completed all of the steps in an Idea, they are able to go back to redo any step if they want additional practice. Select the submenu option to see how many times they've completed each step. This provides the number of puzzles completed. So, if you have assigned a plan with a redo, the report will state that the student completed the puzzle twice.

Clicking the 'Show Current Progress' option will display how many puzzle pieces the student has completed vs. how many were assigned to them. If the student was given a plan with a redo, two fractions will appear on their report. The bold one indicates the current progress – if it's on the left then the student is on the first puzzle of the plan, if it's on the right then the student is working on the second puzzle assigned by the plan.

Plans

A teacher may feel that the default plan is ill-suited to their stronger or weaker students. One can tailor the students' experience of ELM through the *Plans* feature. The *Plans* tab allows a teacher to control how their students will progress through ELM by modifying how many puzzles and/or puzzle pieces they should complete in order to successfully master each step.

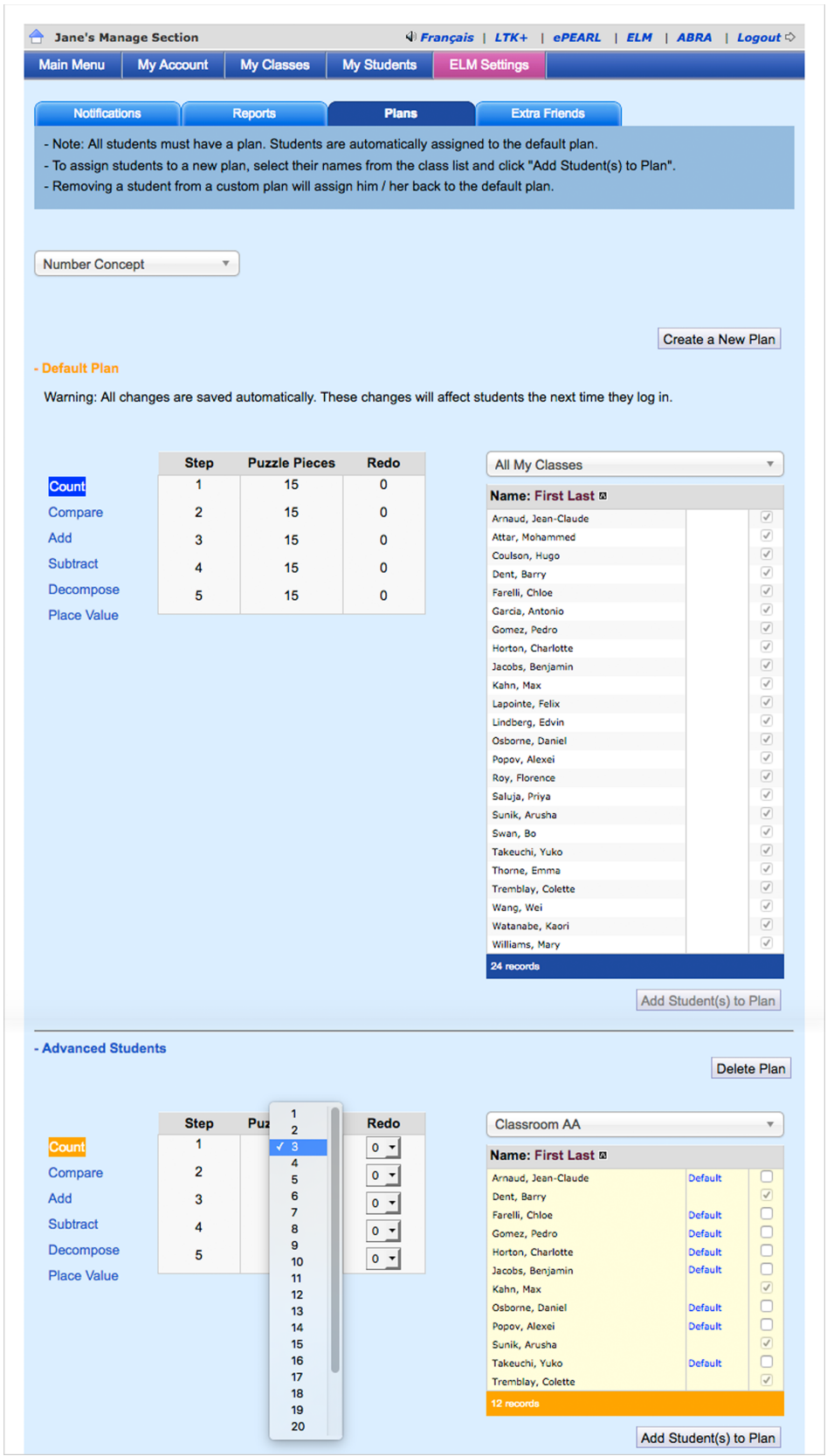
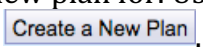


Figure 105: Teacher Manage, Plan Tab

The first step is to select a theme to create a new plan for. Use the dropdown menu at the top of the page. The click on the button 

. Enter a name for the plan in the textbox that appears and click on 'save'. The plan will load at the bottom of the page. The class dropdown list can be used to narrow down the list of students, but a plan can be applied across multiple classes.

There are two methods that allow for additional practice of a particular concept: puzzle pieces and redos. For each step, a teacher can adjust the number of puzzle pieces (repetitions) to anywhere between 1-24. One can increase the number if it is desired that a student practice more, or decrease this number if a student should advance more quickly to the more challenging tasks. The student will only gain the new "animal friend" once they have completed all of the repetitions.

Teacher Tip: There is no option to skip a step even for the advanced students. Even if they are asked to complete only one puzzle piece, it will provide students to opportunity to become familiar with the tool.

The plan can assign a redo of the puzzle, with the same number of puzzle repetitions. This provides additional practice for to help student master skills and strategies.

Teacher Tip: One option of how to use the redo feature could be to provide encouragement to the students that are struggling. For example, if the default plan for the whole class is set to 15 repetitions, a teacher can create a plan that has a redo but only 10 missing puzzle pieces in each puzzle for the weaker students. This will require them to do more repetitions in order to move on to the next step, but they gain the friend mid-way through to provide encouragement sooner.

Each student can only be assigned to one plan per Idea. Students' current plans are listed next to their names. Students can be moved to another plan at any time. If the student is working in ELM when their assigned plan is changed, the plan will only take effect the next time they log in.

Once a plan has been created, it can be kept even if no students are assigned to it. Plans can be reused from year to year.

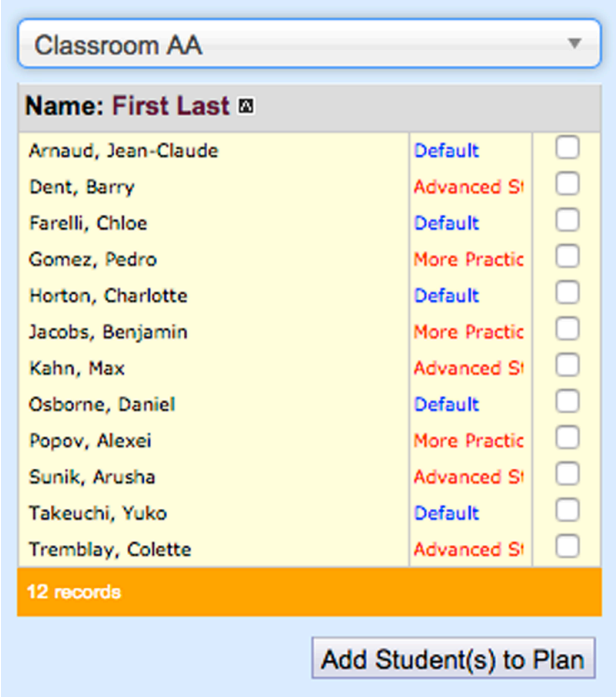


Figure 106: Teacher Manage, Plans Tab – Example Class List with Different Plans

Extra Friends

The *Extra Friends* tab contains some additional animal friends that are not linked to specific online steps. A teacher can choose to assign these if ELM's offline lesson plans or ELM's suggested extension activities are used, or if any introduction activities were created for use within ELM.

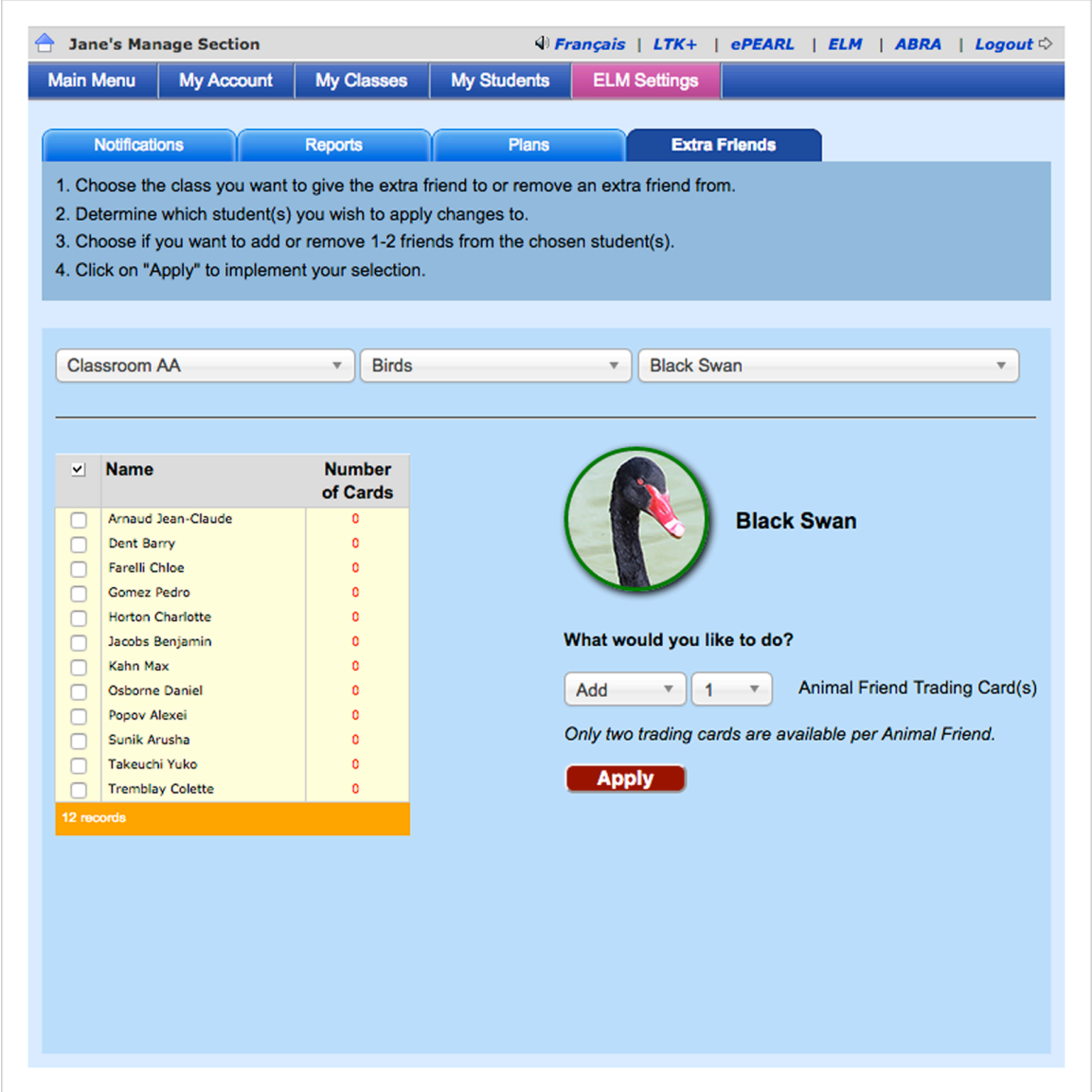


Figure 107: Teacher Manage, Extra Friends

ELM-ePEARL Link

The link between the ELM and ePEARL tools supports the development of students' self-regulated learning skills. This is an ideal space to prompt students to reflect on the math skills they are building and incorporate their daily practices with classroom lessons.

In order to access this feature, the student must go through the ePEARL tool. First click on the *My Creations* button  . On the *My Creations* page, there will be an ELM creation button.

Teacher Tip: If you do not see this button in ePEARL, or the ELM tool in the LTK lobby, then ELM has been turned off by the system administrator. Please contact them to access the tool and all of its features.

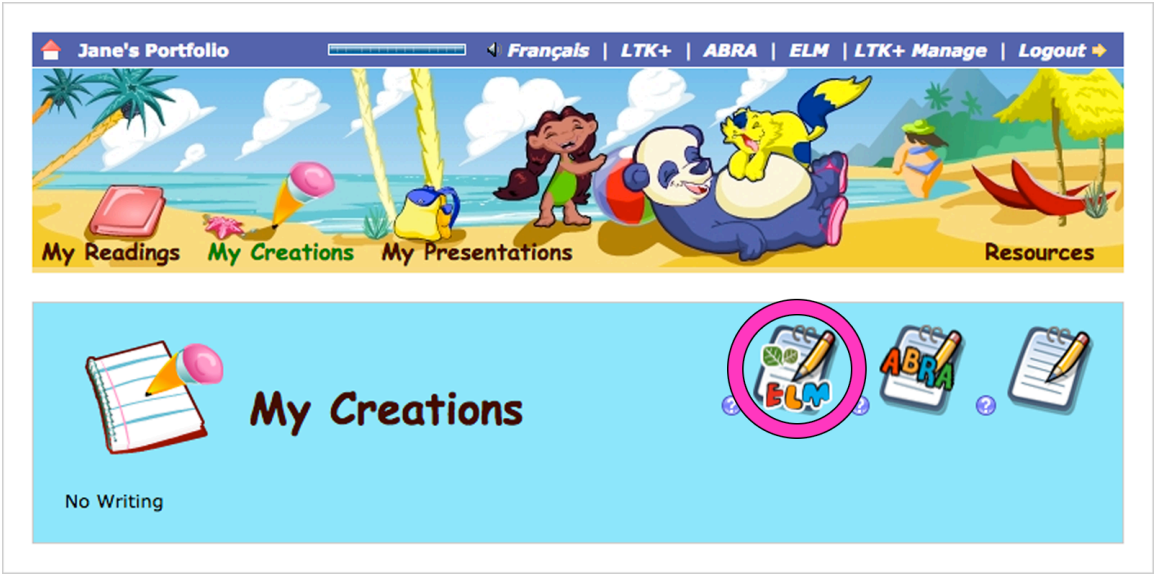
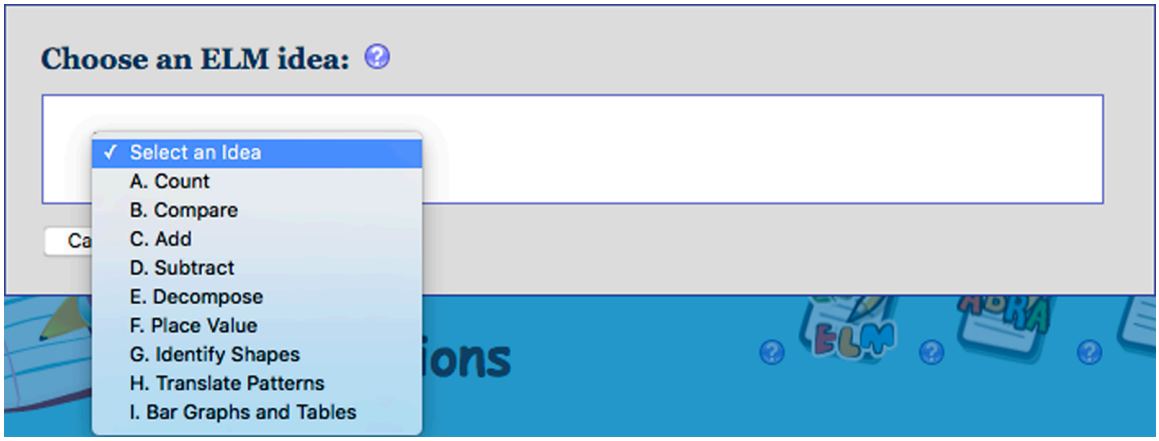


Figure 108: ePEARL, My Creations – ELM Creation Button

Students will first be asked to select an Idea:



Teacher Tip: As some students are may be struggling readers, one can guide them to select a particular Idea using the alphabetized list. For example, to reflect on *Decompose*, guide them to select "E".

Students can use the *What I Want To Do* section to create goals related to the Idea. For example, a goal related to Identify Shapes could be "I want to learn 2 new shapes today".

Teacher Tip: Young students are likely to be more comfortable using the recorder feature.

The *My Creations* section can be used in a number of ways in ELM. Students can indicate how they practice their math skills. Or a teacher can tie these skills to other subject areas: write a story that incorporates the math skill used, or draw a picture of how the student is using this skill in real-life settings.

The *Reflections* section allows students to consider how the mathematical concepts they are learning about relate to their lives and/or track their learning. The dropdown list provides suggested questions, but students can create their own by typing in the text field then clicking on the *Add* button.

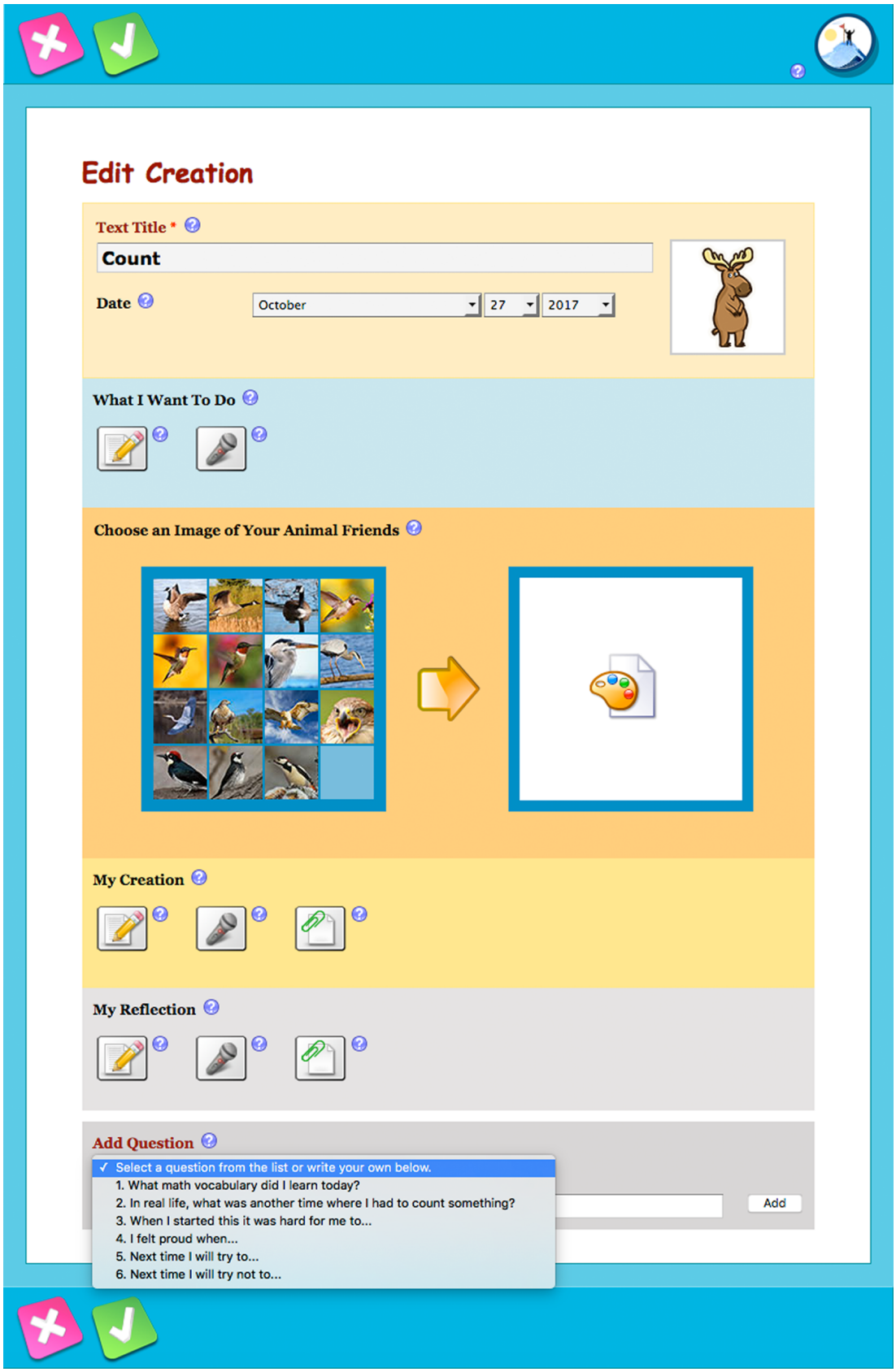


Figure 109: ELM Creation

Parent Module

The Parent Module (http://grover.concordia.ca/resources/elm/parent/en/) provides a similar resource targeted towards parents and guardians. Parents should be encouraged to access this resource to learn how to support use of ELM at home.

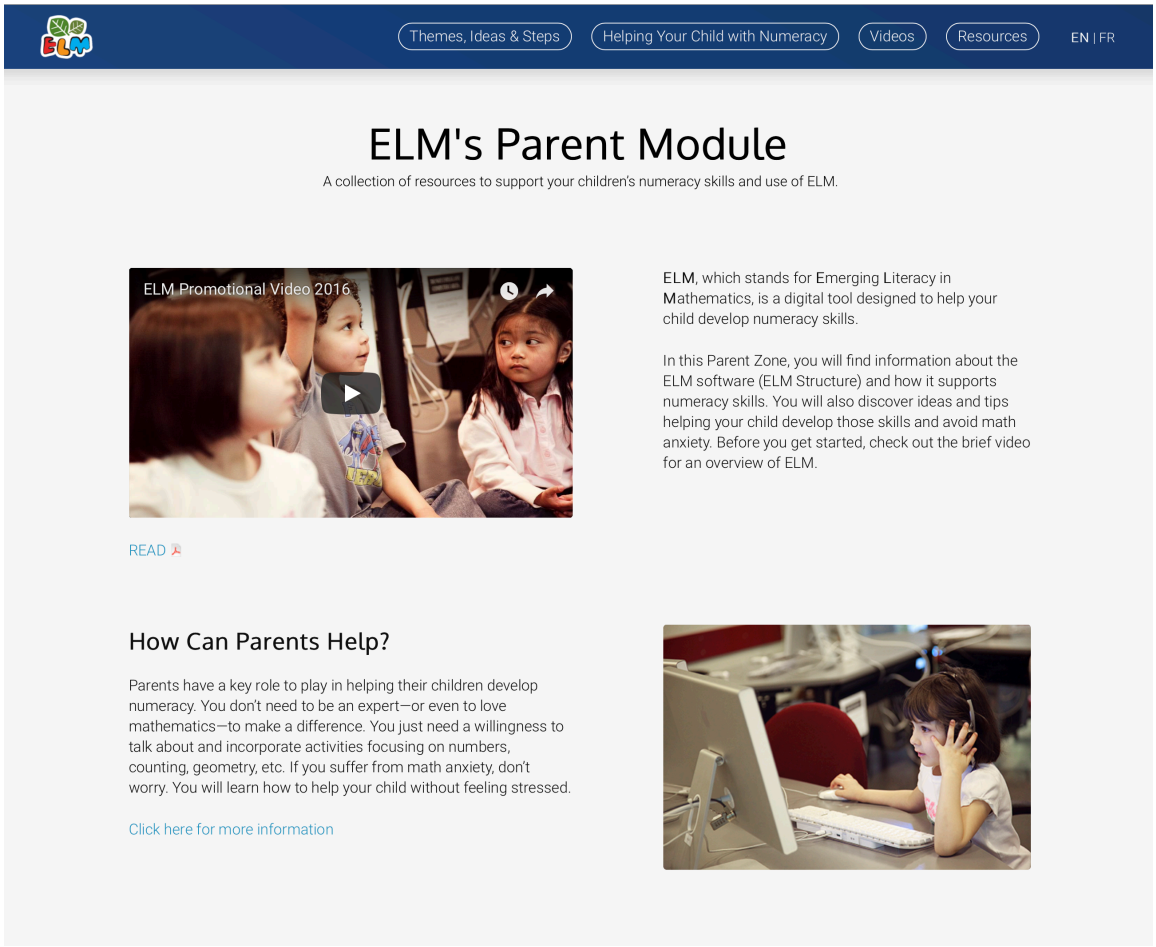


Figure 110: The Parent Module