Geometric Visualization of Algebraic Operations

A Resource for K-12 Schools

---Client Meeting Notes---

Client: Dr. Bardzell || mjbardzell@salisbury.edu
Professor: Dr. S. Wang || spwang@salisbury.edu
Team Name: Team Fraction Abstraction
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Notes from 9/7/20 meeting with client:

(47 minutes long)
Browser can be done but is harder. Go for Executable.
Look into PC first. Multiplatform (Ipad) [optional]
Pick a language. Python Java recommended.
Different difficulty levels give user more or less info (cuts, all operations, etc)
Denominator limit (2, 3, 4, 5, 6, 7, 8, 9, 10) For now. Hard limit TBD
Game Engines are typically 3D, but we need 2D. Most likely a no-no for Game Engine. If 2D option exists maybe?

Collision: If User cuts square in half when problem is in sixths. Mouse event click and drag shaded smaller square. If Shaded square not big enough, then rectangle snaps it back.
Check for square "Sizes" to verify legal move. When 'close enough', snap in place.

Potential back and forth for operations.

Multiplication Example with only one square: 'area one' (⅓ * ⅖). Slice square in thirds vertically, then horizontally slice square into fifths. User needs to shade appropriately. User clicks one area and a third is shaded vert. User click one area and 2 fifths are shaded. OVERLAPPING AREA = ANSWER.

Addition Example with 2 squares: ⅓ + ⅖ . Cut and shade third on S1. 2 fifths on S2. Add needs Common denominator so make complimentary cuts on both squares. Click and drag shaded spots from on square to the other, avoiding already shaded spots.

Slicing: outlines vs draw yourself. 1st level outlines for easiness. Harder difficulty can have tic marks to represent which cuts represent what. Hover over tic = display which size. Click draws all cuts of that size for them.

Mouse Events for drag and drop and adjust colors to show what can/can't move. THIS NEEDS PRIORITY. Dr. Wang can help with advice.

No solution sets/walkthrough. Leave explanations/teaching to students. No Tutorials yay!!! User can make their "own" fractions in some mode and use random numbers.

Mixed numbers for maybe next semester. Negatives are ‘’’’Red’’’’’’

Focus on Making cuts and shading and movement.

Notes from 9/14/20 meeting with client:

(40 minutes)
Division Example problem: ⅓ / ½ : Draw a box of 'area one'. Cut into thirds. Shade in one third. The divisor of ½ asks to divide ⅓ into a half although ½ is bigger. Draw a new box. Cut into pieces of one half. The shaded area can NOT fill a cut half. Thirds and halves do not mix well, so we find a common denominator. Cut Box 1 in half horizontally. Cut Box 2 in thirds Horizontally. Click and drag a piece of the shaded area from Box 1 into any of the six open boxes in Box 2. We are now in a highlighted container of box 2 that is size one half. We have filled two thirds of one half, so our answer is ⅔.
(a milk analogy helps as well)
Division Example problem: ½ / ⅓ : Draw box 1 of 'area one'. Cut Box 1 into halves. Shade in how much you have. Draw Box 2 of 'area one'. Cut Box 2 into thirds. Find common denominator by cutting into thirds horizontally in Box 1. Find common denominator by cutting into halves horizontally in Box 2. Although the rectangles are in different orientations, the area of the shaded partitions are the same. Drag and drop shaded spots from Box 1 to Box 2. After 2 partitions dragged and dropped, we have filled one full container of size one third. At the end, we have a half full container of size one third. So our solution is 1 ½ or 3/2.

Depending on student level, the user will have to make their own cuts. Have them hover over tics to display what fraction. After clicking the tic the cuts would be made for lower level.

(Avoid Negatives for now. Negative area will be dealt with later)
(Subtraction is Bigger minus Smaller. Could potentially be in one square)
Subtraction Example Problem in one square: ⅗ - ⅓ : Draw Box 1 of 'area one'. Cut Box into fifths. Shade in 3 of those fifths. Cut Box 1 horizontally into thirds. Shade in area of one third. Note: There IS overlap. [Fun idea, have a waste basket to subtract the Green from the Blue.] Remove the overlapped pieces into the "Waste Basket". The pieces not overlapped then snap to become overlapped. Then remove to the Waste Basket. Count the remaining pieces. So our solution is 4/15.
(Test subtraction with one or two squares with children.)
(Have dialogue for making a mistake)
(Have a hint bubble for dialogue on what to do) ***Client likes this idea
Either a software tutorial or the teacher would show.
Subtraction Example Problem with two squares: ⅗ - ⅓ : Draw Box 1 of 'area one'. Cut into fifths. Shade what you have. Draw Box 2 of 'area one'. Cut into thirds horizontally. Shade what there is. Cut Box 1 into thirds horizontally. Cut Box 2 into fifths horizontally. Combine two spots of the same size then it will be thrown into the Waste Basket. Kids would like that sort of animation for box cancellation. Either into trash or they FIZZLE OUT That's so cool.

We could make it open source for pip install, but it would be better for it to be independent to make it an exe without python.

Notes from 9/21/20 meeting with client:

(20 Minutes)
Confirmed that python executable can be created and done without python on receiving computer.
Push for having one square for implementation for now.
Multiplication example with two squares: 1 ½ * ⅓ : Draw Square 1 filled in fully and fill in Square 2 filled in half. Cut Square 1 into thirds horizontally and same with Square 2. Shade in the overlap of ⅓ then shade ⅓ of Square 2 and note the overlap. Issue found: ⅓ + ⅙ . Come back and cut Square one in half vertically to have overlapped squares be the same size. 2/6 + 1/3 = ½.
Deal with less than two squares. This would be something harder, intended for upper level.
Division and Subtraction does not need 2 Squares per se. Same with Multiplication.
Higher level is not the size of the number but how much information needs to be moved or modified. Make high level kids make cuts and shade in.
Short Term: Cut up squares and move. When and how it snaps.
Draw squares first. Cut drag and drop. Figure out Cutting. The user can put a point and drop down to hav it be a measure. Drag and drop physics.

Notes from 9/28/20 meeting with client:

(15 Minutes)
Showcased rudimentary rectangle creation, mouse events, and cut creation.
Asked about holding and maintaining cuts, not implemented yet.
How are sub rectangles going to be implemented? We plan on reducing the real rectangle with division.
Defining sub rectangles will be tough.
How will we keep track of rectangles, using an array?
Multiplication can be done in one square with no drag and drop with fractions less than one.
Start on piece pick up and movement. Huge priority wanted by client.
Have a “valid” area. Have rotation for snapping into place as well.
The physics will be hard to deal with and should be addressed.

Notes from 10/5/20 meeting with client:

Showcased rectangle creation and cut creation. Rudimentary click and drag.
Need to isolate for one at a time. Need to have a “legal move” checker.
Dr. Bardzell says the cutting and moving physics is one of the main challenges.
Throw a boolean value for inactive then when click.
Start making a second rectangle to have click and drag after legal move checking.
Try looking at Towers of Hanoi, a simple game. Note how the drag and snap into place is coded.
Main priority click and drag, menu and other UI aspects will be dealt with later.
Second rectangle and check for rotation. Have a program/function do a 90’ rotation for putting a rectangle down in a new spot. Only need a snap and drop no animation needed.
Think about implementing sounds instead of moving animations, etc.

Notes from 10/12/20 meeting with client:

Showed Dr. Bardzell a working example of the drag and drop rectangle process.
Need to work on what happens when a student makes wrong cuts. Have the size fit inequality be shown and it teaches them when they are wrong.
Need scale of different fraction cuts for initial cuts. Long term think of being able to show what proportion of fraction cut (⅕ ¼ ⅓ ½)

Asked about Rescheduling Next week to Noon Monday (10/19)

Notes from 10/19/20 meeting with client:

Showcased working rectangle snapback with rotation.
Showcased variable cutting. We need to be able to scale in order to deal with larger fraction denominators.We want to be able to show kids the relative size of rectangles in regards to the denominator of a fraction.
Idea: Upper left corner to show if they are close to or next to with the fraction equivalent. How to make them think of relative size, we want to show students how ⅕ is less than ⅓ ? Maybe a collision area for where users hover over. Focus on a low cap on the denominator (Max of 6 or ⅙) to determine where and what size cut. When the user finds one third, click and then draw all cuts for one third. Constrain all collison checkers to one half of the rectangle.
Reschedule our meeting for 12:15, if early send

Notes from 10/26/20 meeting with client:

Showed our new fraction cutting process (with all cuts displayed) and Dr. Bardzell approves.
Look into fraction operations, this is where we begin to implement the different problem types. The multiplication steps will be as follows:

1) Make vertical cuts
2) Shade vertical rectangles
3) Make horizontal cuts
4) Shade remaining rectangles

For example, if we color vertical rectangles blue, and horizontal rectangles red, the overlap (in purple) would be the answer to the multiplication problem.
We will alter the state manager and maybe create different state managers for each type of fraction arithmetic problem.
We will add a shading state in order to keep things clean.
In the future we may have a way to reduce fractions and deal with mixed numbers.