
FractionSketch: An Electronic Whiteboard for Teaching Fractions

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Abstract

In this paper we propose a new electronic whiteboard system for teaching fractions, a fundamental math topic that is often problematic for students. A field interview with an elementary school teacher and an examination of a math textbook that is common in Japanese public schools produced a set of usage scenarios that motivated our tool. The result, FractionSketch, allows teachers to sketch shapes that are commonly used to teach fractions, such as circles, rectangles, and number lines. Teachers can then manipulate these objects, divide them, and recombine them in ways that are useful for teaching both simple and advanced topics. Educators who evaluated our interface found it intuitive, easy to use, and believed that the interactive presentation methods could be motivating and enriching for students.

Keywords

Fractions, math education, sketch-based interaction

ACM Classification Keywords

K.3.1 Computer Uses in Education: Computer-Assisted Instruction (CAI)

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Introduction

Learning fractions is a major goal of elementary school mathematics. However, since operations with fractions are notoriously difficult to demonstrate, fractions can be challenging to teach. Fractions are often considered to be one of the most challenging math topics of elementary school [2].

An initial interview with an elementary school teacher and examination of a standard textbook provided us with some knowledge of the techniques and tools that are used to teach fractions. Traditional methods for teaching fractions include standard whiteboards and physical manipulatives such as cookies and measuring tape. Whiteboards enable teachers to sketch various shapes and figures and introduce mathematical notation. However, these diagrams are static and cannot be manipulated. Conversely, physical manipulatives are interactive and connect directly to real-world situations that involve fractions, but can be expensive to provide for each student and are difficult to connect with mathematical notation.

As projectors become more widespread in schools, teachers are increasingly able to show visual material from a computer to the entire class. This material typically consists of images and animations that have been created by experts and are minimally interactive. Since interactivity is important for demonstrating mathematical concepts, we determined that there is a need for a new tool that would assist teachers create such visualizations for fractions.

Our system, FractionSketch, attempts to combine the advantages of both whiteboards and physical manipulatives, enabling teachers to sketch shapes that

become real and can be manipulated like real-world objects. Users can perform tasks that are important for teaching fractions, such as dividing a whole and recombining its parts, through simple sketches. As a result, with very little learning time, teachers can use FractionSketch to demonstrate a wide variety of subtopics within the domain of fractions. In an initial evaluation of FractionSketch, three teachers were able to learn how to use the system in about ten minutes and were able to design a variety of lessons using it.

Interview with Elementary School Teacher

Hoping to learn more about the methods that are currently used to teach fractions, we interviewed an elementary school teacher. We asked her to explain how she teaches a wide variety of fraction concepts, particularly focusing on tools and methods. We also examined a textbook that she recommended.

From these sources, we learned that rectangles, circles, number lines are commonly used on a whiteboard to visualize fractions. Circles correspond to physical manipulatives like cookies and pizzas, which can be divided radially. Similarly, rectangles correspond to objects like brownies and cakes, and can be divided horizontally and vertically. Number lines are commonly used to show the relationships between numbers.

We also observed that groupings of fractional pieces are important. For example, when teachers wish to teach addition, they might physically move a piece of pie from one pie tray to another, or they might try to draw diagrams and indicate this movement on a whiteboard. Therefore, we tried to facilitate movement and grouping in FractionSketch.



Figure 1: FractionSketch interface.

FractionSketch

In this section we will describe our tool. FractionSketch is an electronic whiteboard system that is intended for classroom use by a teacher with access to projector. It is implemented in Adobe Flash ActionScript 3.0.

Our system features three basic shapes that teachers commonly draw when teaching fractions: circles, rectangles, and number lines. Fraction objects can be through sketching or from a set of templates. If a user draws a circle or a rectangle with a single stroke, the system recognizes the shape and creates the appropriate object. Number lines are created by drawing a horizontal line and a vertical line on each end of the horizontal line. For recognition we use the \$1 classifier proposed by Wobbrock et al. in [3]. The creation of these objects can be seen in Figure 2.

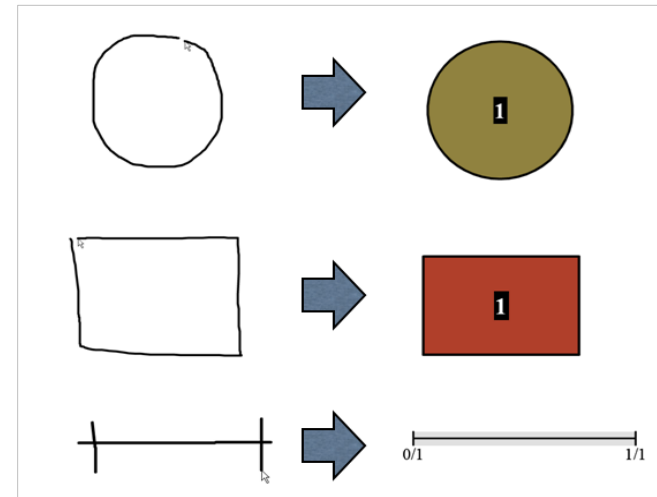


Figure 2: Creation of objects.

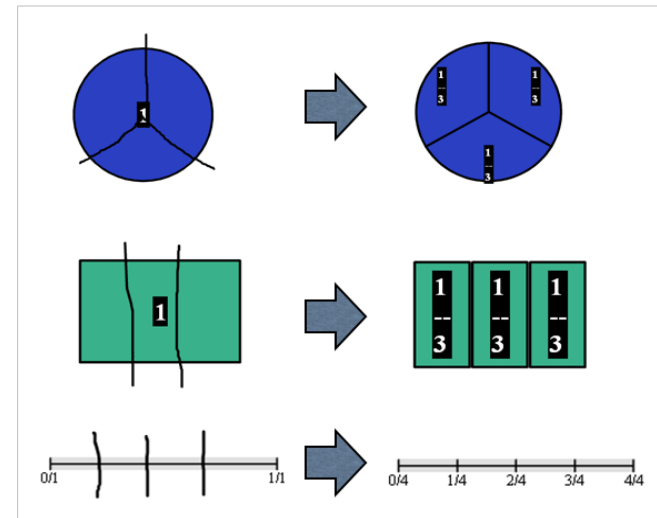


Figure 3: Division of objects.

Objects can be dragged and scaled. The whole which the object is a piece of can also be visualized. In order to divide an object, the user sketches lines over the object and then taps somewhere on the whiteboard (Figure 3). The object is always divided equally. Fractional pieces can then be combined together. When one object is dragged close to another object, they snap together and become a larger composite object.

$$\frac{1}{2} + \frac{1}{4}$$

$$\frac{1}{4} + \frac{1}{4} + \frac{1}{4} = \frac{3}{4}$$

Figure 4: Example showing addition.

Evaluation

We conducted an informal evaluation of our system by asking three teachers to use it. The teachers had all taught fractions in elementary schools in Chiba Prefecture, Japan. We first asked each teacher to complete a guided walkthrough of FractionSketch. Then, we asked the teacher to design lessons using our system to teach some subtopics of fractions.

All of the teachers were able to learn how to use FractionSketch in about five minutes, and they successfully created all of the assigned lessons without significant assistance. When asked what they liked or

did not like about FractionSketch, the teachers all said that they liked the interface for drawing shapes and dividing them. They all said that the system was easy to learn, and one said that it is intuitive. One teacher claimed that a third grader could figure out how to use the system in five minutes. The teachers complained about missing features, for example, that the system is unable to support liquids and containers.

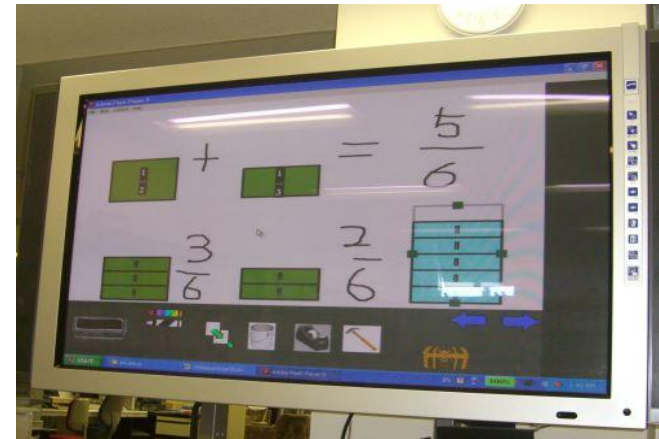


Figure 5: Lesson created by a teacher with FractionSketch.

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