Exploring Digital Quilt Design Using Manipulatives as a Math Learning Tool

K. K. Lamberty, Janet L. Kolodner
College of Computing, Georgia Institute of Technology, Atlanta, GA 30332-0280
Tel: (404) 894-5534, Fax: (404) 894-5041
Email: {kristin, jlk}@cc.gatech.edu

Abstract: How can we incorporate math manipulatives into the curriculum in such a way that they promote understanding, foster creativity, and support other curricular areas in parallel with math? This is the question we wish to answer in the DigiQuilt project.

Introduction

Research in education has shown that learning about fractions can be difficult. Many curricula used in elementary schools incorporate the use of manipulatives such as pattern tiles, fraction sticks, and fraction pies to offer tangible, physical representations of math concepts. With manipulatives like pattern tiles, learners may discover relationships between shapes and how to fit them together in beautiful patterns. Our goal is to take advantage of this observation – to incorporate manipulatives into math and other areas of the curriculum such as art so that they promote understanding, foster creativity, and connect curricular areas. Constructionist (Papert, 1991) and Learning by Design (LBD) (Kolodner et. al., 1998, 2002) approaches both suggest taking a design approach to fostering engagement with and understanding of complex concepts (i.e., asking students to design patterns using manipulatives). Both suggest that a design approach affords learning not only concepts, but also design skills and skills involved in completing a project. We propose that patchwork and mosaic design projects provide plausible media to promote understanding of concepts in math (such as fractions, area, and perimeter) and art (such as symmetry and balance). Further, we propose that virtual manipulatives provide some affordances for learning that physical manipulatives lack. With this foundation in mind, we are designing a software environment and a set of challenges and activities that integrate learning math and art. Learners design patchwork quilt blocks to learn about fractions and simple art concepts.

DigiQuilt: The system and its use in the classroom

DigiQuilt (Figure 1, center) is a digital construction kit for designing quilt blocks. Users create quilt blocks by selecting shapes from a palette and placing them into a grid. Users can rotate shapes and combine them to make patterns. For ease of making good-looking designs and talking about the math, all the shapes fit together easily and are sized as whole, half, or one-fourth of the granularity of the grids provided as a framework for the designs. DigiQuilt offers a workspace with a grid, buttons for saving images and clearing the grid, a shape palette with buttons to change their colors, and facilities for rotating shapes and copying designs so that they can be easily repeated. DigiQuilt has the learner move the shapes to create the designs; much like physical manipulatives.

Our intention in integrating DigiQuilt into the classroom is to begin with introductory activities using physical manipulatives and to present an overall challenge and then a series of smaller challenges. For each design challenge, the learners will work in pairs or small groups using either DigiQuilt or physical manipulatives. After several design challenges are met, the small groups will get together to share their designs and describe their solutions. Discussions guided by the teacher will help students see similarities and differences across their designs, extract trends and abstractions, and promote understanding using designs as anchors for discussion.

The Study

Is patchwork a plausible medium for learning about fractions and symmetry? How can we orchestrate activities using virtual manipulatives to promote learning through design? What can using physical manipulatives tell us about designing virtual ones? These are the questions we set out to answer in our first study. To understand more about using patchwork design to learn math, and, more specifically, a digital version of patchwork design as a medium for understanding math, the first author worked with 21 third grade students in a classroom setting using DigiQuilt and a paper version of the same manipulatives, providing assistance when needed and helping them notice what they could learn. The students completed design challenges involving symmetry or fractions. Figure 1's left and center segments show solutions to the challenge: design a quilt block that is ½ one color and ½ another color.

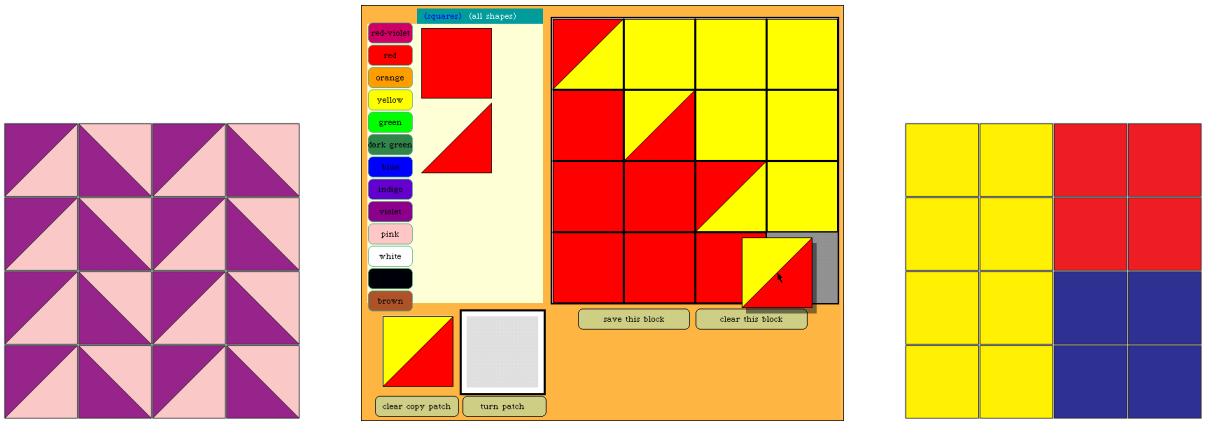

Figure 1. The DigiQuilt software featuring examples created by third graders using the system

As students worked on more difficult challenges, (e.g., the challenge design a quilt block that is ½ yellow, ¼ blue, and 2/8 red was on that many students found difficult (example solution shown in Figure 1, right)), the support techniques we used informed new facilities the software might need in order to better support the learning. For example, emphasizing different ways to look at the workspace or different parts of the grid helped learners understand more about equivalent fractions. Another technique that worked for two students was helping them figure out the fraction first and then make the design, either by giving them the exact number of pieces needed or by helping them set up a work area to gather a set of shapes themselves that fit the fraction. Facilities for overlaying different grids on the design, checking for symmetry, changing colors used, working from previous designs, and "undoing" previous actions will afford a smoother design process, thus promoting further exploration. More information about the study may be found online at http://www.cc.gatech.edu/~kristin/DigiQuilt/.

Discussion

All of the students were able to understand the easier challenges and create interesting designs to achieve them. With some scaffolding, most students were able to understand the difficult fractions. In both groups, when students struggled to understand the math needed to solve the challenge, they were less inclined to continue on with that challenge and make a more interesting design. We need to make the math-learning fall out of the design process more intuitively to prevent this sort of frustration. The tools we propose may help ease this frustration.

Merging art and math through design projects (specifically using patchwork) thus seems to be a plausible medium for learning about symmetry and fractions. This study also suggests that while digital or virtual manipulatives offer some affordances that the paper or physical manipulatives may lack, the physical version is still useful for getting started and helping students with specific (unanticipated) learning issues. The physical version of the patchwork environment helped uncover what the software needs to have to be effective as a learning tool, and the software in its current version helped us see some ideas for changes and other directions for the future. Making different tools available to encourage the learner to notice particular concepts using quilt design, this medium might be appropriate for a wide range of ages. Future work is needed on the orchestration and special purpose scaffolding to make patchwork design work for learning about fractions, symmetry, area, perimeter, shapes, color, and pattern.

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Acknowledgments

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