By: Lynae Sakshaug and Kay Wohlhuter

Virtual Tile Turning

Introduction

Understanding transformations requires students to use spatial reasoning skills. The activity discussed in this article is a task that challenges students to visualize slides, flips, and turns of a shape using electronic pattern blocks. As identified by Clements and Sarama (2000), the use of on-screen manipulatives ensures that all students have enough pattern blocks to use and encourages students "to act on manipulatives in ways that are more in line with the mental actions that we want students to learn" (p. 460). During this task, students used an electronic set of Pattern Blocks created by Jacobo Bulaevsky and made available here with his permission. When using this electronic set, students determine how moving a piece at a time will situate the shape instead of clicking on a button to do the desired move.

Several teachers tried this activity with their students. After the task is presented, we will discuss the trends identified by our examination of teachers' reflections and their students' results.

The Activity - Virtual Shape Turning

Students begin the activity by creating a shape using at least three pattern blocks. They use multiple representations of the shape as they record their pattern-block creation on isometric grid paper. Students will record their transformed shape on grid paper and on the electronic mat. To facilitate their exploration, teachers should make sure that students practice using the electronic pattern blocks before attempting the problem. To work with the blocks, click on them and drag them to a place on the grid. Click on buttons at the top to see what they will do. The instructions button at the bottom of the page also describes how each button is used.

Part 1:

Using at least three different pattern blocks, create a solid shape by placing each block next to another block so that they share an edge. Make the shape irregular so that not all the opposite sides will match if shapes are folded over on each other. Draw the shape on isometric grid paper.

- **Transformation ONE:** On your grid paper, draw what your shape would look like if you moved it halfway across the paper from its original place. After drawing it, create the figure on the electronic mat. Does your drawing look like the figure on your electronic mat? Why or why not?

  The kind of move you just made is called a *slide*. Label your drawing "slide." Now slide your shape back to its original position.

- **Transformation TWO:** On your grid paper draw what the shape would look like if you turned it over. After drawing it, create the figure on the electronic mat. Does the drawing look like the figure on your electronic mat? Why or why not?

  The kind of move you just made is called a *flip*. Label your drawing "Flip." Now flip your shape back to its original position.

- **Transformation THREE:** On your grid paper, draw what the shape would look like if you turned it 180 degrees or if the top was turned to where the bottom was and vice versa. After drawing it, create the figure on the electronic mat. Does the drawing look like the figure on your electronic mat? Why or why not?

  The kind of move you just made is called a *turn*. Label your drawing "Turn." Now turn your shape back to its original position.

Part 2:

Fool a friend! Create a move with your shape that combines both a flip and a turn. Have a friend tell you which transformations were used and in what order. How did they do? Is there more than one way to describe how it was moved? Hint: You may want to try different turns, not just a 180 degree turn.

Part 3:

Are there shapes that are harder to manipulate? Are there shapes that are easier to manipulate? What makes some harder than others to slide, flip, and turn?

Thoughts on writing such a problem

As the authors wrote this activity, some questions arose:

- Would the amount of reading required to do this activity limit its availability for use by some of the children?
- Would the children be comfortable with the technology?
- Is the technology being used in a meaningful way or just as an add-on?
- Is this a meaningful activity situation that helps children develop a better understanding of transformations or just an excuse to use some fun technology?
- Would we know more about students' thinking with regard to transformations as a result of the interaction?

We hoped to have answers to these questions after having students try the activity.

To gain a better understanding of how this scenario would proceed, we asked twelve teachers in New York and Iowa to use this activity in their classrooms during June. Several of the questions above were answered as the teachers and students shared their many valuable insights. A summary of the answers and insights are included here.

Lessons from students' work

Students in grades 1 through 7 completed this investigation. Their work showed that an activity posed electronically could be accessible to different-aged students. Several teachers expressed that the students caught on much more quickly than the teachers thought they would. Students confidently determined how the program worked and explored the activities posed with the applet. The students appeared to be comfortable with the technology. Some of the students said that they would like the software to do the transformation for them and thus allow them to check their work. Other students were confident that their solutions were correct without having the computer check their solutions. It would be interesting to have the students who felt the need to have their work checked talk with those who knew they were right. A discussion of the reasoning behind knowing if the transformation was right could prove meaningful for those who were unsure.

The reading did prove to be an issue with some of the students. For some the amount of reading was overwhelming. Where there was a need for support, the teacher stepped in and helped the children with reading. Other children chose to skip some of the reading. A further conversation with the students would help in rethinking the wording of the activity.

One interesting result came from the language the children chose to use in discussing the activity. While the terms slide, flip, and turn were included, some children chose to use other rich language to describe the movements their shapes were doing. For example, one teacher commented that a child in her class was comfortable using the language of the 180 degree turn that they were doing with the shape. Although the half turn was referred to alternately as a 180 degree turn in the activity, the teacher was surprised that the child used the language so comfortably. Another child brought some descriptive language of motion into the conversation as he used the term "tipping" when he was doing a slide. That child was talking about how there were times when he was supposed to be sliding and instead he was envisioning tipping the shape on its side. His language nicely captured the notion of turning the shape. Some of the older students discussed vertical symmetry or using a line of symmetry as an important characteristic of the figure that helped in flipping the tile. Lindquist and Clements (2001) describe how the Principles and Standards for School Mathematics "call for even the youngest children to be introduced to mathematical language but in a natural way that connects with their informal language" (p. 411). The teachers and authors were able to see some examples of children being able to incorporate the language of geometry into their discussions and writing while inventing their own language and attaching meaning to it based on the activity. They were connecting the language of transformations to their own informal language.

The use of a visual pattern was beneficial when doing transformations. One group of younger students described using a “blue wave” to help them focus on how the tile would move during a flip or a turn. In this situation, there was a snake of blue rhombi (create this model here) through the tile. The snake helped with orientation. If the blue rhombi were placed correctly, the other pieces were relatively easy to place.

Two aspects of the activity interfered with students’ understanding or generated alternative solutions. One aspect involved what was meant by a flip. One error made by some of the students was to interpret a flip as meaning that each piece was flipped separately instead of flipping the whole shape. Another thing that interfered was the labeling. Some students drew the flips and turns in the right way but labeled them backward, perhaps indicating some confusion over which was which. If students labeled the drawings after the fact, it may have been harder to distinguish between the two movements. In those instances, further conversation with the students about their understanding would have been very helpful.

Lessons from the teachers

Before the students worked on the activity, the teachers expressed their concern that students would have difficulty figuring out the technology. Some teachers were surprised with how quickly students became comfortable with it. In some cases, the students were more comfortable with the technology than their teachers.

Teachers’ misconceptions surfaced in their reflections about using this activity. Some felt that the flip needed to be done in one particular way. They were not comfortable with the range of flips that were generated. Some teachers said that a button that would do the transformation would be preferable, thus not seeing the need for the students to model what the transformation would look like.

Teachers’ comments also provided suggestions for future use of this activity. One teacher stated that indicating a specific range for the number of tiles would have helped her class finish the drawing task. They had a limited amount of time to work on this activity. Some students’ interpretation of “at least three” meant fifteen tiles. Students spent so much time drawing and coloring their elaborate figures that they did not have time to do the entire activity. Another teacher felt that having students use colors to draw their figures and to record the results facilitated the students’ work with the activity.

Lessons from looking at several sets of work

Examination of several sets of students’ work found that this activity gave students opportunities to communicate mathematically, use various mathematical representations, reason mathematically, and problem solve. Students communicated their thinking as they drew pictures and used their own language as they wrote about the activity. The use of isometric grid paper by some students made it easier for them to represent their tiles when drawing. Had others had the grid paper, instead of plain paper, it might have led them to be able to compare their drawings with the electronic tiles more easily. Tied to this was the importance of using various forms of representations—pattern-block manipulatives, paper drawings, and electronic drawings. Each representation required the use of spatial reasoning.

The degree to which students engaged in problem solving depended on students’ previous experiences and teachers’ comfort level. The students’ prior knowledge determined whether this activity was new and different or not. For some students, this activity was an investigation. For others, it was an application of previously learned information. Some teachers were more comfortable letting the students try things on their own. Their students, in turn, seemed to be more comfortable with experimenting and were more confident about their results without needing to check them. The teachers who wanted to give more guidance viewed this experience as being much less successful. The teachers who wanted to provide more guidance were not necessarily those at the lower grades.

Conclusions and opportunities

Students' work also generated interesting variations of the original activity. One group of students created a treasure hunt with the electronic pattern block board. They hid pieces behind others, and students had to figure out what pieces were hiding. The students talked about how you could use strategies to figure out which pieces were hidden from what was known about the shapes.

One sixth grader used the pattern blocks to create a shape that actually appeared to be a three-dimensional figure. Positioning the tan rhombi was the key for highlighting the three-dimensional nature of the picture. The student's ability to model and draw this connection produced a powerful illustration of her knowledge.

We saw again, as in the past, that when students were in control of the situation rather than having the teacher guide them, the students did well, were creative, and were successful. Students were also more independent in their reasoning about results when they were in control.

The information from students' exploration of this activity and the creation of the Illuminations Shape Tool (http: illuminations.nctm.org/mathlets/shapetool/index.html) provide us with opportunities to further explore the activity posed in this article. We would like you to try this activity with your students using the Shape Tool applet and the following guidelines.

Practice using the Shape Tool applet: select a pattern block by clicking it, and then clicking again at the place on the grid where you want the block to appear. (If you keep clicking on blocks, new ones will appear.) To erase a block, click on the lightning bolt tool, then click on the block you want erased. To move a block around the grid, click on the arrow tool, then click on the block you wish to move. Place one or more blocks on the electronic mat. Try some of the action tools along the left column of the applet to see how they transform the blocks.

To build a shape: move the pattern blocks into the shape you desire on the electronic mat. Now select pairs of blocks by either dragging a rectangle that selects two blocks or by pointing with the arrow tool to a block, holding down the shift key, then pointing to the next block and releasing the shift key. Once a pair of blocks is selected, click on the GLUE tool and the blocks become one shape. Keep doing this until all blocks are connected into your shape. If you want to start over, erase your shape using the lightning tool.

To help students understand and visualize different transformations, have them create a shape and then try sliding, flipping, and turning the shape. First, students should predict how the transformation works on paper, then, using the Shape Tool applet, they can see it work dynamically on the computer's screen.

As your students are working, when possible, let them figure out what they think is being asked with little help from you. It would be fine if they worked with a partner. If you would, share the following information after you observe the children solving the activity by emailing lsakshau@brockport.edu.

- What went well as the children solved this activity?
- What did they seem to struggle with?
- Describe whether the children liked the interactive Shape Tool mat.
- What surprised you about how the children solved the activity?
- This activity involved a good deal of reading. Did that seem to be problematic?
- What recommendations would you give to change or improve the activity?

For other opportunities to explore problems using electronic pattern blocks, see the references section.

about the authors

Lynae Sakshaug

Lynae Sakshaug is invovled in research on learning mathematics through meaningful problem solving. She is also involved in action research in urban education in the Rochester City School District, Rochester, NY. Lynae teaches mathematics education at SUNY Brockport.

Kay A. Wohlhuter

Kay Wohlhuter, kwohlhut@d.umn.edu, teaches at the University of MN Duluth, Duluth, MN 55812. Her professional interests include the teaching and learning of geometry, the examination of the use of technology in the mathematics classroom, and the professional development of preservice and inservice teachers.

references

Clements, Douglas H., and Julie Sarama. "Tech Time: Predicting Pattern Blocks on and off the Computer." *Teaching Children Mathematics* 6 (March 2000): 458–62.

Lindquist, Mary M., and Douglas H. Clements. "Principles and Standards: Geometry Must Be Vital." *Teaching Children Mathematics* 7 (March 2001): 409–15.

National Council of Teachers of Mathematics (NCTM). *Principles and Standards for School Mathematics*. Reston, Va.: NCTM, 2000.

Sakshaug, Lynae. "Problem Solvers: The Mathematics of Motion." *Teaching Children Mathematics* 6 (December 1999): 250–51.