Using a Tessellation Program as a Mindtool

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ABSTRACT

There are many articles of theory and abstract philosophy on the concept of mindtools, but few actual examples of how to apply them. Since Jonassen first introduced the idea of mindtools in 1998, educators have explored using computer applications to develop deeper thinking in their students. They have provided some generalized software suggestions but few concrete examples.

This paper will examine software written by Jay Crook that creates interactive tessellations. Does the software qualify as a mindtool? To answer this, some groundwork needs to be established. What is the definition of mindtools? What exactly are tessellations? And how do they complement each other?

To fully understand the discussion of the tessellation tool, it is important for the reader to download the tool and experience it as well. It can be downloaded or installed from the following URLs to your PC (Mac is not supported):

http://www.jaycrook.com/jay/T-install.exe (to install)

http://www.jaycrook.com/jay/Tessel.exe (to download).

LITERATURE REVIEW

In the 60s, the Spirograph excited kids of all ages with the visual beauty of mathematics. The simple toy of a gear within a gear made art out of geometry and trigonometry.

In the 70's the kaleidoscope experienced a resurgence in popularity. The mirror filled tube became a popular toy for children and they learned the beauty of reflection and repetition.

For cheap entertainment, kids have glued toothpicks end-to-end making interesting geometric shapes.

All of these "toys" were used to teach children about tessellations. They may not understand the mathematics behind the objects, but the children were able to see aesthetics in the repetition.

Mindtools

This study will explore a few of the concepts of Jonassen's Mindtools as they relate to the tessellation software.

A mindtool is computer application that was developed or repurposed, not as an instructor for the student, but as a partner in the learning process, to motivate and facilitate critical thinking. A mindtool is a "cognitive tool" to take care of some basic tasks and rely on the intelligence of the student, not the computer

(Jonassen, Carr & Yueh, 1998). Its goal is not to make the processing easier, but to make more effective use of the mental efforts of the student (Birgit & Sisley, 2007).

Mindtools facilitates intentional, student-centered knowledge construction where the student learns from experiences developed during the project (Mitchell, 2005; Irving & George, 2000). The mindtool becomes an important ingredient in constructing an environment that both challenges the student and requires higher order processing of new information (Irving & George, 2000).

In an educational setting, computer-based mindtools are not dependent on application software, but on the creativity of teachers and students (Wilcox, Bauschard & Osterhus, 1998).

Since critical thinking and higher order learning can also play a prominent role during professional work, mindtools are also intellectual partners with the worker where working and learning are intertwined (Kirschner & Erkens, 2006). They can also be used as an intellectual partner that enhances the cognitive powers of human beings during thinking, problem solving, and learning (Jonassen & Reeves, 1996).

Tessellations

A tessellation can be defined as a pattern of one or more shapes, completely covering a surface without gaps or overlaps (Furne, Goodman & Meeks, 2004). The mathematics of tessellations lie in the way the pattern repeats itself, and which geometrical transformations are combined (Pumfrey & Beardon, 2002).

Tessellations can be found in everyday life, both in nature (e.g.: fish scales, tortoise shell, pineapple, ear of corn and honeycomb) and man-made objects (e.g.: brickwork, wallpaper, floor tiles and quilting). They are of interest to people from artists to mathematicians.

Tessellations are interesting to students requiring creativity and problem solving. In their simplest form, they are used as an applied math activity for young children. In their most complex form, they provide challenges to mathematicians and artist alike, whether attempting to tessellate flat surfaces or three dimensional objects such as spheres (Johnson & Kashef, 1996).

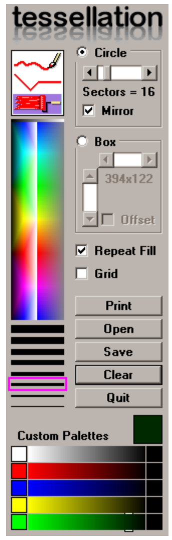
Possibly, the man most associated with tessellations was Dutch artist M.C. Escher, who was inspired by the mosaics of Islamic art in Spain. His illustrations incorporated tessellations and/or metamorphoses. He had powers of visualization that gave him a superior intuitive understanding of geometry. Escher gained a great deal of respect from mathematicians for his work and he lectured on art, mathematics and science (Pumfrey & Beardon, 2002).

Another notable figure was Roger Penrose, who was known for the Penrose tessellation, which is a pattern that appears to repeat but does not.

A Tessellation Mindtool?

Crook's tessellation software can create regular, semi-regular, rotational, reflective and complex tessellations. The tool is simple enough for a preschooler to use, and is flexible enough to provide continued learning as the student progresses. Students at any grade level will find a variety of ways to use tessellations.

The tool supports the use of reflections and rotations. Transformations are used to create tessellations with slides, turns and flips. It can be used to develop spatial ideas using the properties of shapes and symmetry.



The tessellation program begins with a blank canvas and drawing tools on the left side. “Some of the best programs begin with a blank screen upon which students can apply their creative imagination and talents” (Hertzog & Klein, 2005). As the student draws on the screen they see reflective and/or repetitive drawing occurring. Automatic feedback engages students and becomes a motivational side effect (Pigford & Baur, 1995).

Children develop geometrical insight during the creation of tessellations. Teachers should not assume that all students visualize tiling patterns in the same way. People tend to be either left brain (logical, mathematical) or right brain (creative, artistic). Tessellations will appeal to both types. Owens and Outhred (1997) described young children’s difficulty with visualizing tiling patterns, particularly when the shape to be tiled was unfamiliar.

So can this program be repurposed as a mindtool? Jonassen (2000) provides a short list for evaluating any application. It must be:

1. Computer-based
2. Available
3. Affordable (under $100)
4. Used to construct and represent content or personal knowledge
5. Used in different areas or subjects
6. Able to deepen critical thinking
7. Facilitate transferable learning
8. Formulate, organize and represent knowledge in a somewhat different way
9. Easily learnable (within 1 to 2 hours)

The tool meets all of those standards. Focusing more on the sixth feature, Davies (1997) said a mindtool is to engage the student in critical thinking using some of the following features:

- Nonalgorithmic: the steps required to solve a problem are not completely identified in advance
- Complex: the complete solution is multi-dimensional
- Often yields multiple solutions
- Involves nuanced judgment interpretation
- Involves multiple, sometimes conflicting, criteria
- Involves self-regulation of thinking process (nobody else dictates each step to take)
- Requires finding meaning and structure in apparent disorder
- Requires considerable mental effort, elaborations and judgments are required

Surprisingly, the tool meets most of those criteria. The tessellation program allows the student more space for originality and creativity. Students can use it to interpret and organize their personal knowledge.

Jonassen (1998) said technologies should not support learning by attempting to instruct the students, but rather should be used as knowledge construction tools that students learn with, not from. This tessellation software would qualify for three of his categories.

1. Semantic Networking: It can spatially represent ideas and their interrelationships. The semantic network is to represent the structure of knowledge constructed by the student.
2. Microworld: It can create objects, and test their effects on one another. This visualization tool helps students to represent and convey their mental images. There are no general-purpose visualization tools, but they tend to be specific to certain kinds of visuals.
3. Knowledge Construction: When students function as designers of objects, they learn more about those objects than they would from studying about them.

This mindtool broadens the student's thought process while creating designs and ideas that would be impossible without this or a similar tool. It keeps the student actively engaged in creating and reflecting on their creations.

Good software encourages children to talk about their work as well as engage in more advanced cognitive types of play. "When technology is used effectively, it creates an active interaction between student and content. The complexity of these interactions increases with the level of student talent" (Hertzog & Klein, 2005).

Tessellations and Mathematics

Although tessellation has mathematical applications in fields as diverse as biology, architecture and physics, in the mathematics curriculum the topic tends to be included as a means of developing students' understanding of geometrical ideas, rather than as a worthwhile mathematical idea in its own right (National Council of Teachers of Mathematics (NCTM), 2000). There are five levels of increasing complexity when reasoning about the geometry of tessellations (Callingham, 2004):

1. Visualization: Students only notice the appearance of the shape, and describe properties only in terms of its appearance.
2. Analysis: Students describe properties informally, and can establish the essential conditions through a consideration of component parts.
3. Abstraction: Students can draw on logic to establish necessary and sufficient conditions when describing the properties of shapes.
4. Deduction: Using formal reasoning systems, students can establish theorems and rely on proof as the ultimate authority.
5. Rigour: Students can move outside a single system and compare and contrast geometries that are based on different premises.

These pedagogical shifts of the NCTM goals include - a shift toward connecting mathematics, its ideas, and its applications - away from treating mathematics as a body of isolated concepts and procedures (National Council of Teachers and Mathematicians, 1991).

The tool fits into NCTM goals. These are important and can help students to build on larger ideas of reasoning and proof as they advance mathematically (Furne, Goodman & Meeks, 2004).

Technology should be incorporated into the mathematics curriculum in such a way that permits students to connect mathematics with diverse fields and applications, and to put mathematic ideas into action (Harvey & Charnitski, 1998).

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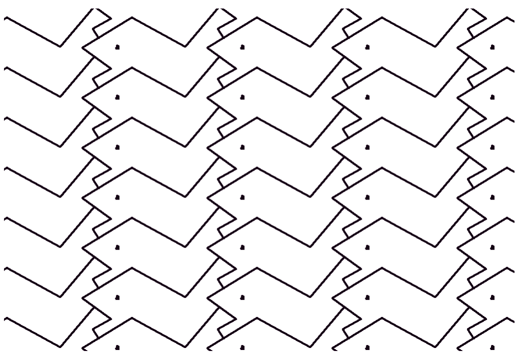
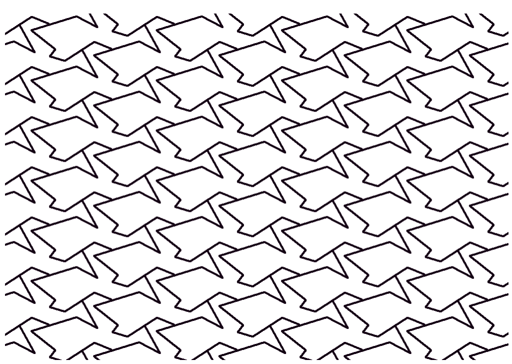
ATTACHMENTS

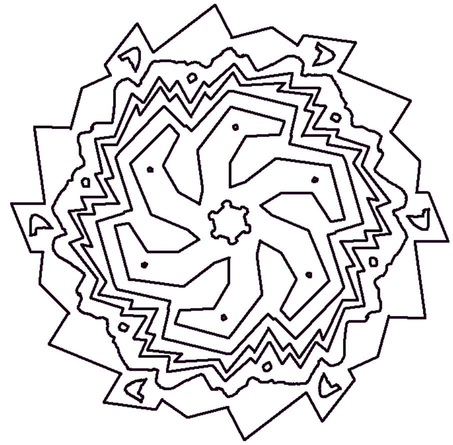
Examples of the various types of tessellations that the software can generate:



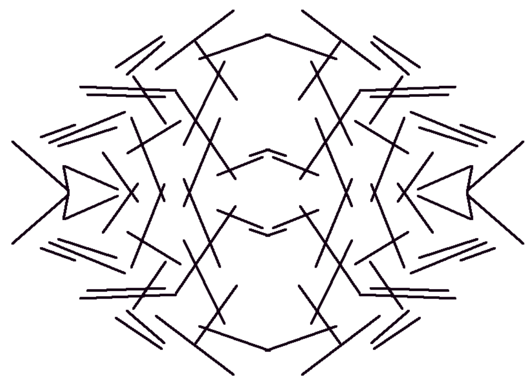
A Regular Tessellation



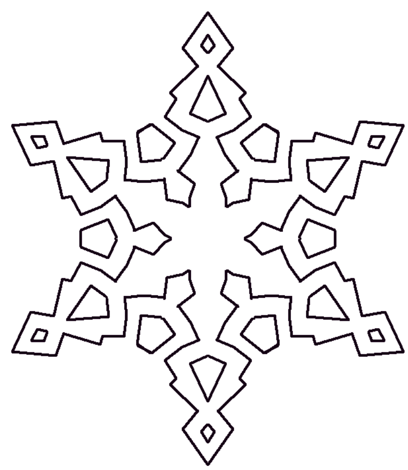
A Semi-Regular Tessellation



A Rotational Tessellation



A Reflective Tessellation



A Complex Tessellation

A sampling of student artwork: