Lesson Plan on Rubik's Cube Mosaics: An Intermediate guide for use in the classroom

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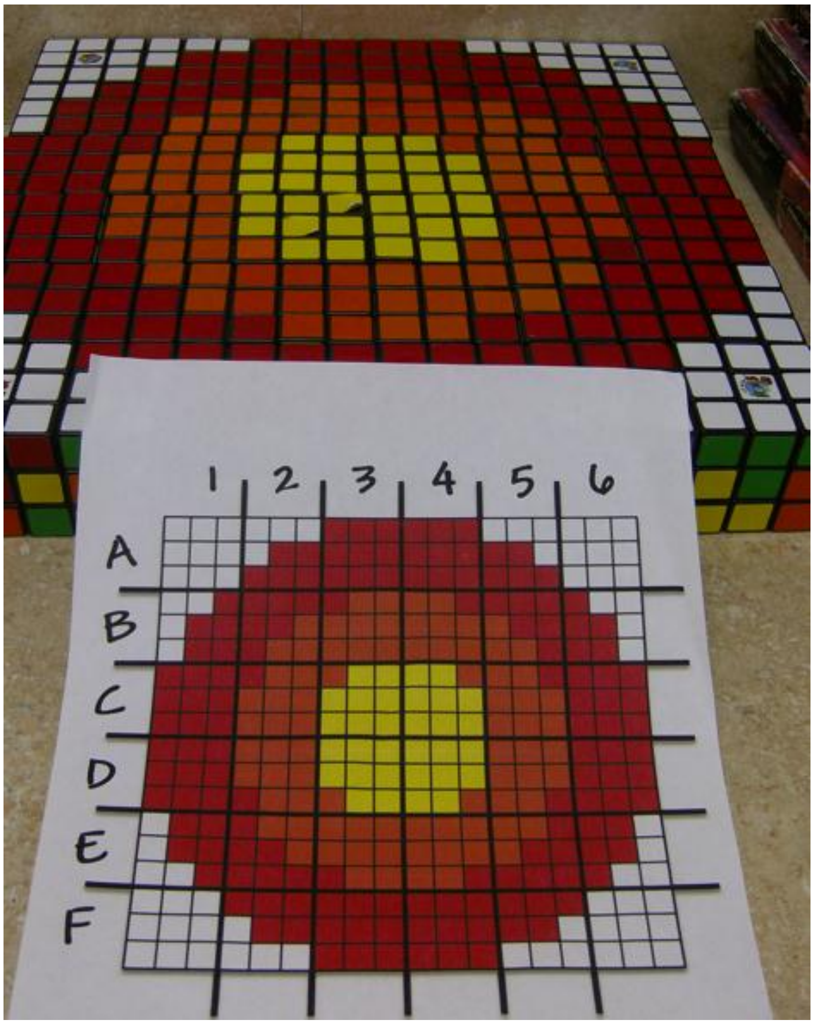
Algebra 2, Geometry, and Statistics



Learning to solve the Rubik's Cube is a great warm-up activity. In many classes I teach (Algebra 2, Geometry, and post Exam AP Statistics), students come into class during a specified time period (about 3 weeks) and grab a cube. Each day they learn a new algorithm for solving. It takes three days for me to teach students to solve the first two layers and then 3 or 4 more days to solve the entire cube. In an 84-minute block, we devote about 10-15 minutes to cubing. Students enjoy hands on problem solving. They rise to the challenge and feel smart and accomplished when they can solve a cube without any assistance. Many students have seen the movie, *The Pursuit of Happyness*, where Will Smith solves the cube in the taxicab and captures the attention of a potential employer. In keeping with that theme, my students say that they have **"potential to the exponential"** when they earn their certificate for solving.

Today, mathematics lessons must be written to show alignment with the Common Core State Standards. I have also included the Massachusetts Curriculum Frameworks 2011 in the lesson. To make mosaics with Rubik's Cubes, students engage is problem solving, visual and spatial awareness, reasoning, communication, and representation. Students persevere in problem solving and must find entry points into problems. They reason abstractly and must use tools of technology for making a pixel template.

Common Core State Standards

N.Q. 1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale in graphs.

N.Q. 2 Define the appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Modeling with Geometry G-MG
Apply geometric concepts in modeling situations.
1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

The Standards for Mathematical Practice
Massachusetts Curriculum Framework for Mathematics, March 2011

The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on the following two sets of important "processes and proficiencies," each of which has longstanding importance in mathematics education:

• The NCTM process standards

- problem solving
- reasoning and proof
- communication
- representation
- connections

• The strands of mathematical proficiency specified in the National Research Council's report "Adding It Up"

- adaptive reasoning
- strategic competence
- productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy)

The Standards for Mathematical Practice
1. Make sense of problems and persevere in solving them.
Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler

forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary.

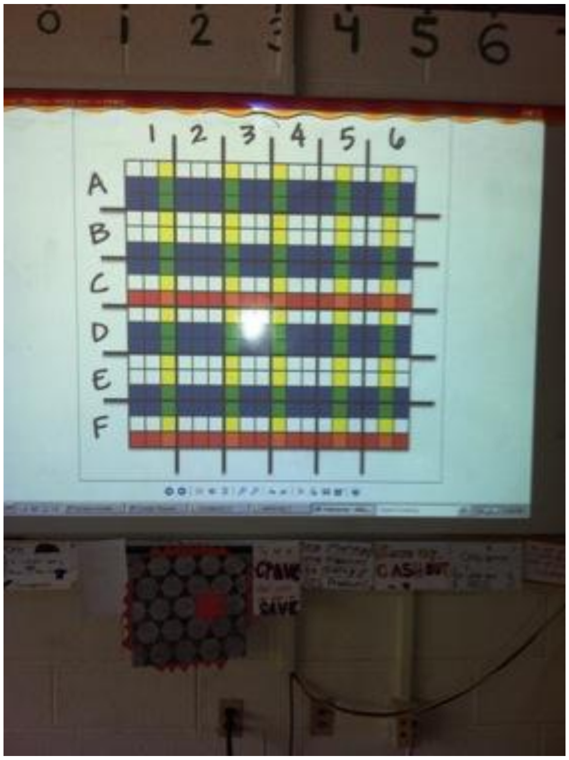
2. Reason abstractly and quantitatively.

Mathematically proficient students make sense of the quantities and their relationships in problem situations. Students bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically, and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meanings of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.

5. Use appropriate tools strategically.

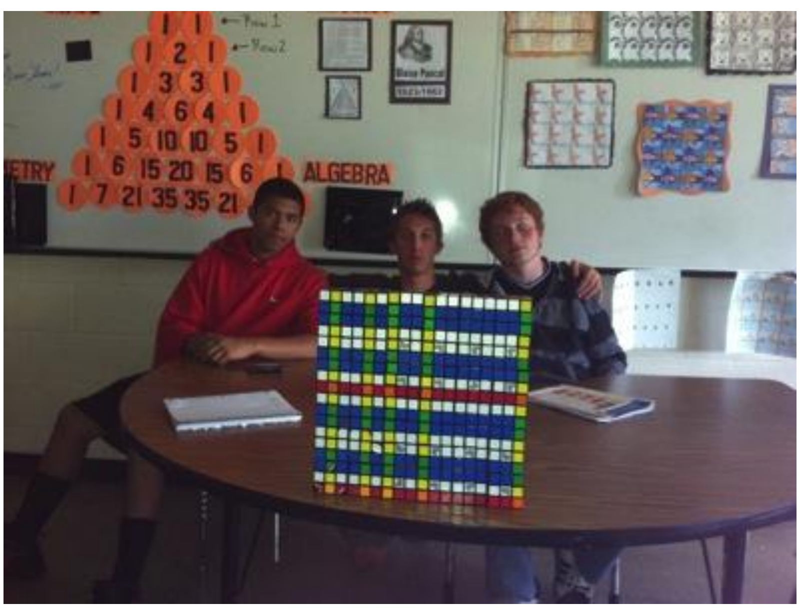
Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.

The curriculum frameworks for modeling with geometry are highlighted below. Building mosaics is a fun way for students to use geometric shapes to describe objects. We used the concept of a pixel per centimeter to make our pixel template with Photoshop. We placed grid lines in our photos using measurement skills. We built a frame for our mosaic and used geometric methods to design the structure to satisfy the physical constraints of 225 cubes, Now for the fun! I would recommend that classes start with a 6x6 mosaic and then try the larger ones on sequential days. My students were left craving the bigger patterns.



To begin, project the template and then assign students to solve a specific row or column. Groups of 3-6 students can typically solve a 36-cube mosaic in about 15 minutes. They do not always achieve perfection as seen below.

It is helpful to have a team leader. Not all members of the team have to be able to solve the cube to be part of the fun. We assigned non-solvers to be project leaders for the 15x15 mosaics. They organized the 9 (25) cube sections based on the template.



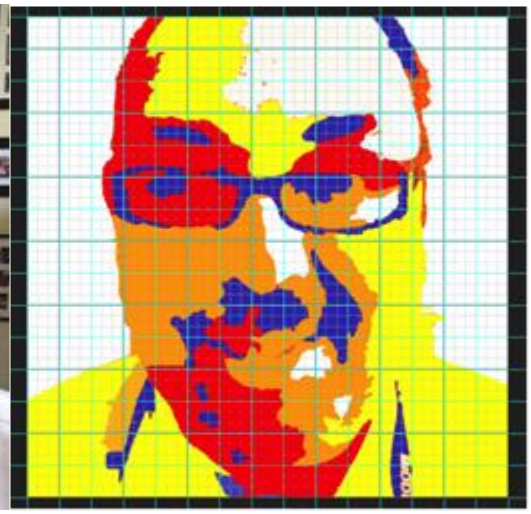
Van Gogh's Starry Night was built during a visit to a Geometry Honors Class. This 100-cube mosaic was a simple start for a room full of beginners. Many students had no formal training but could intuitively solve a side for green. They loved to be part of the action.

Four proficient solvers built Einstein using 225 cubes on my desk in one hour.

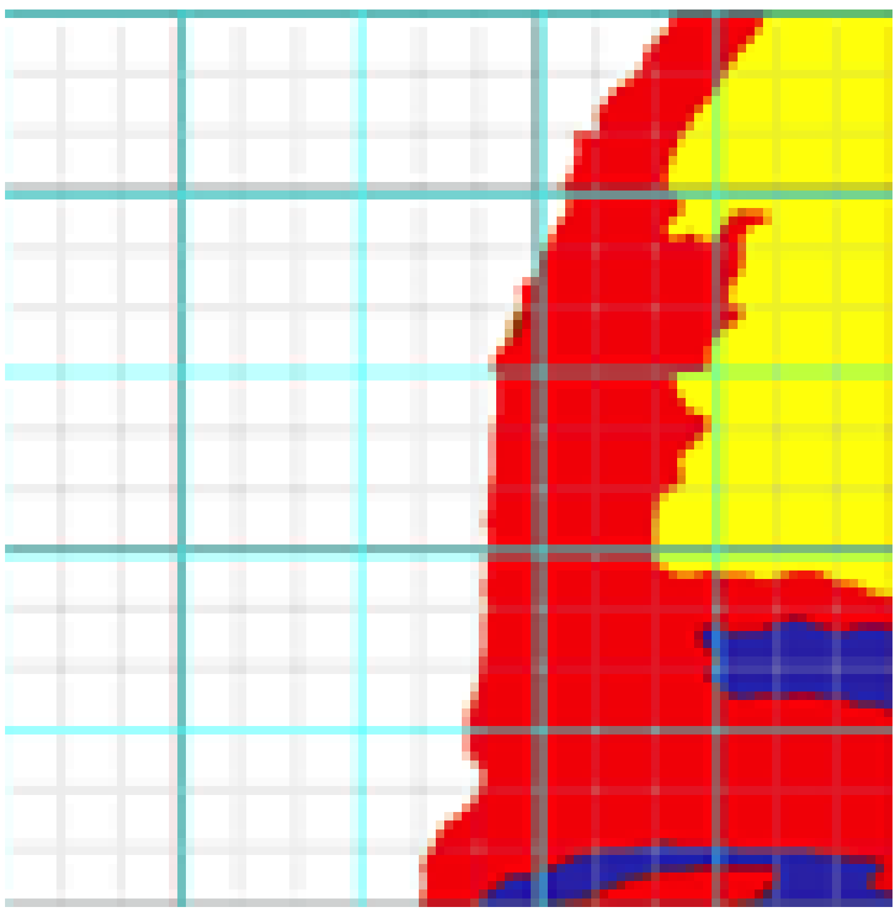
Five students built Abe Lincoln in the cafe. They attracted many interested onlookers.

All of these templates were made available online by You Can Do the Cube.

Now that a 15x15 cube mosaic was easy for us… we wanted to design our own template. Two students asked our Principal for permission to take his photo. They promised a surprise in a few days. There were two options for us to use to design our own computer generated pixel template: GIMP and Photoshop. As luck would have it, a Photoshop 2 class was running during the same block and the teacher was willing to try a cross-curricular project with me. Mrs. Sharon Sangeleer wrote step-by-step instructions for her students to follow so that we could assign cube colors to all 2025 pixels. Her students taught my students how to use Photoshop and my students taught her students how to solve the cube.



This shows the top left section of the designed mosaic. Each square represents one sticker on one cube.



We worked together for 3 days and then unveiled the following mosaic for the school to enjoy.

The white frame was designed and built by a student. The display board allowed us to explain the process of building a mosaic to other students in our school. After many rewrites of the Photoshop directions (attached) anyone can create a mosaic. We tested the directions with several students who had never used Photoshop and they were able to create templates in under an hour.

We worked with the Rubik's cubes for one month. Only 5 full class blocks were used and they were during the last week of school. Students responded very positively to the project. Students were completely engaged in the project. They could not wait to come to class and were slow to leave when the bell rang. They were featured in our local newspaper and their work was highlighted at the Underclassman Awards Night.

We hope to share our excitement with your school and encourage you to try a mosaic of your own.

Please download the Photoshop How To Convert your Picture to a Mosaic from the website:

http://www.youcandothecube.com/cube-mosaics/