Teaching, Learning, and Modeling with Geometry in the Middle and High School Classrooms

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First Project: Geometry Assessments for Secondary Teachers

National Science Foundation DR-K12 Program

Partners

- University of Louisville
- University of Kentucky
- Alpine Testing Solutions - Psychometricians
- Horizon Research Associates - Evaluators
- Advisory Board

Goal

To improve high school geometry teaching through the development of geometry assessments for teachers that provide predictive validity with regard to teaching performance and student achievement in geometry

Content Focus

- Surface Area and Volume
- Congruence and Similarity

Activities

- Analysis of textbooks, standards, videotaped lessons
- Development of a blueprint
- Item writing and written assessment development
- Development of a classroom observation tool
- Study of correlations among these instruments and student achievement

Blueprint for Written Assessment

In the context of surface area/volume and congruence/similarity

- Teachers' knowledge of geometry
- Teachers' knowledge of geometric reasoning and problem solving
- Teachers' geometry knowledge for teaching

Classroom Observation Tool

- Based on teaching "moves and strategies" of Cooney, Davis, Henderson (1975)
- Concepts, generalizations (theorems), and skills/procedures
- Mapped to the Depth of Knowledge (DOK) indicators of Webb (1999)
  - Skills and procedures
  - Conceptual understanding
  - Problem solving/reasoning

Student Assessments

- At the beginning: Geometry readiness test (Usiskin)
- At the end: End of course assessment items (KY)

Preliminary Results

- 72 teachers and 1583 students
- Knowledge of geometry for teaching has greater predictive power for student learning than content knowledge
- Both strong content knowledge and pedagogical content knowledge are necessary for impact on student achievement
- Specifically, teacher performance on DOK 3 items and DOK 3 performance in the classroom revealed higher levels of student achievement

Personal Observations

Observation of high cognitive questioning and active learning classrooms with students engaged in guided construction of new knowledge is uplifting but rarer to see. One can speculate that such learning will carry forward much farther than beyond the next exam or the next year.

Transformations

The topics of surface area/volume and congruence/similarity are strongly associated with geometric transformations of various types. There are some nice pieces of (sometimes free) software that can support learningin this context.

- Dynamic geometry software, such as Geometer's Sketchpad, Cabri, and GeoGebra
- SketchUp
- POV-Ray (ray tracer)
- Blender (has features akin to both SketchUp and POV-Ray) — used in some High School design classes

Second Project: SketchUp in Middle School

- Partner and Project Initiator: Dr. Craig Schroeder, middle school classroom teacher
- 8th grade geometry class, Jessie Clark Middle School, Lexington, KY, 2010 (6 visits)
- 7th grade geometry class, Beaumont Middle School, Lexington, KY, 2014 (5 visits)
- Done during normal class time
- Goal: Engage the students in geometric modeling tasks with SketchUp, with explicit use of geometric objects and transformations, culminating in modeling school classrooms

Activities

- Introduction to SketchUp and some of its tools (with immediate student results)
- Sequence of tasks to build experience
- Measuring and modeling classrooms
- See
  `http://www.ms.uky.edu/~lee/jessieclark/jessieclark.html`
  for some materials and examples

SketchUp Examples

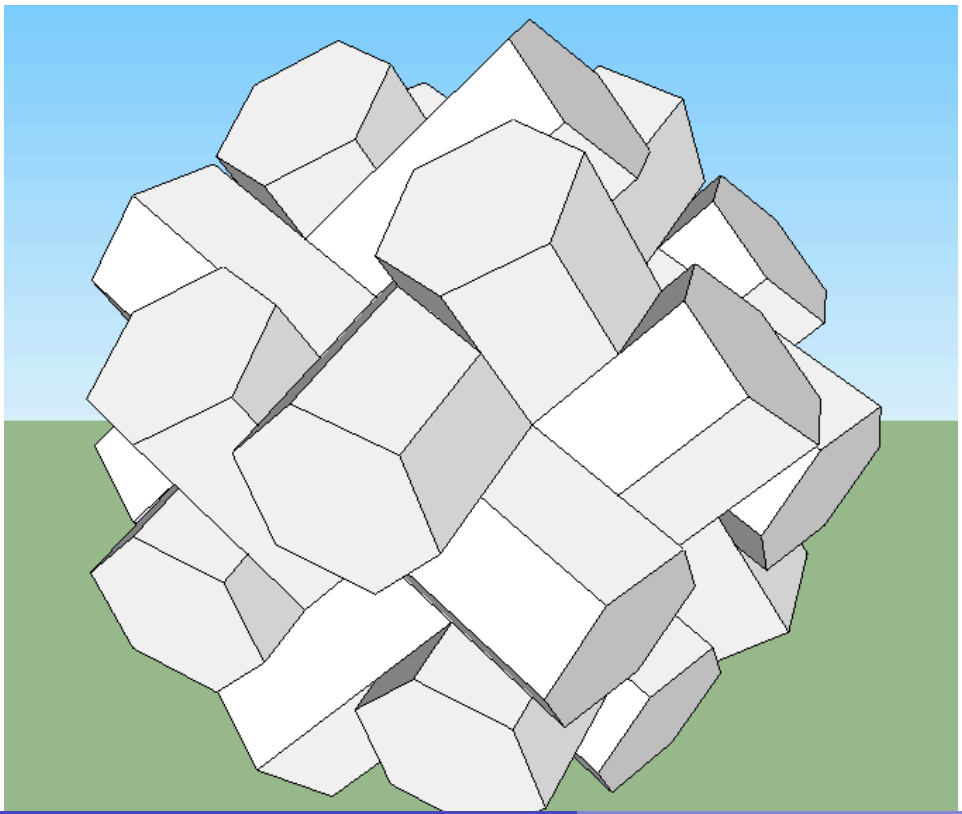
Download software from `http://www.sketchup.com`

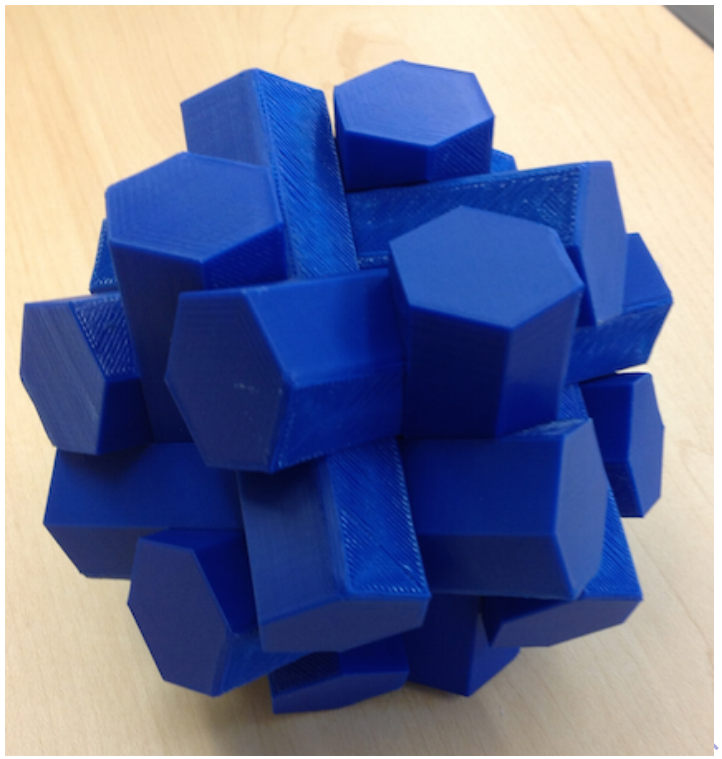
Quick demonstration (if time permits). SketchUp is in its very essence based on construction through geometric transformations.

- Prism
- Translate
- Rotate
- Scale
- Reflect
- Other examples

3D Printing Export

Processed using Makerware,
`http://www.makerbot.com/makerware`, and printed by MakerBot



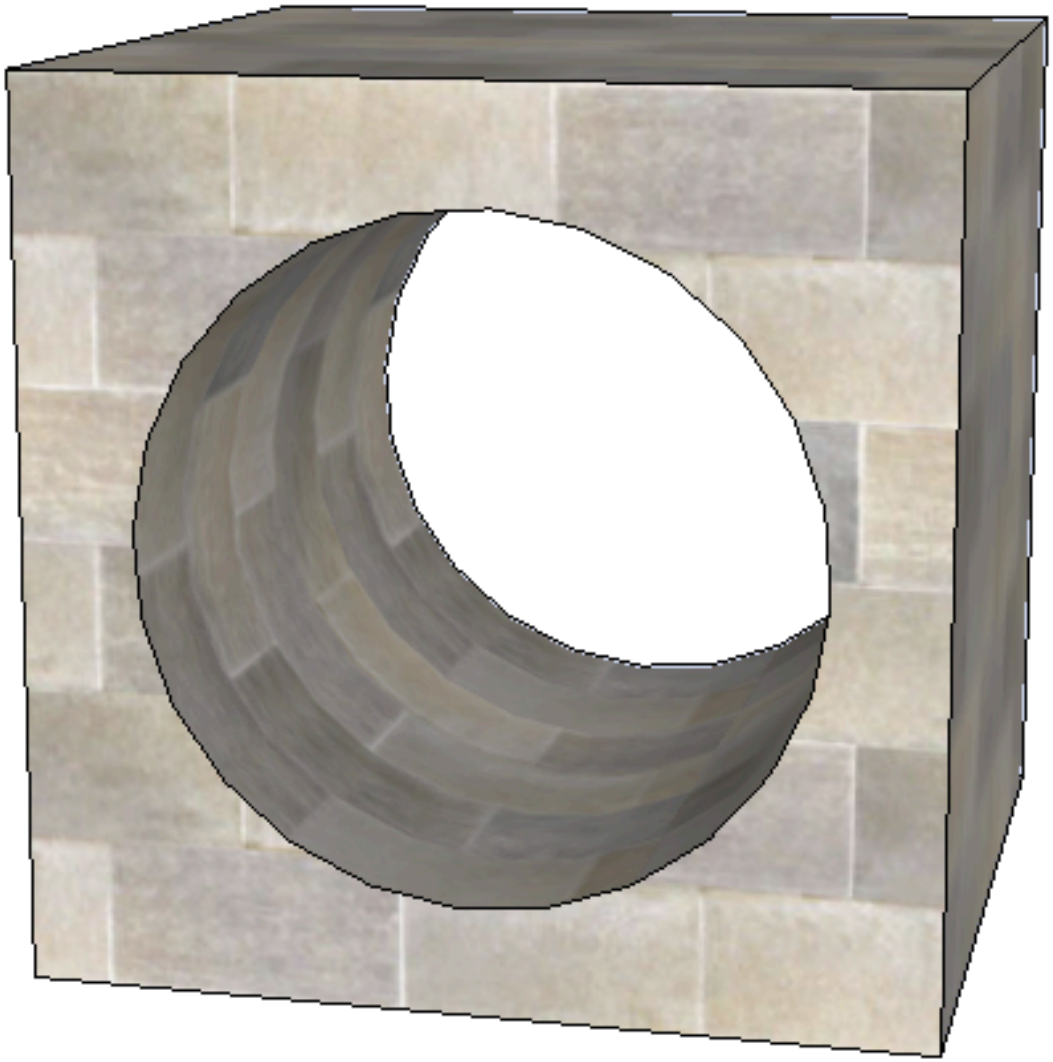


SketchUp Examples from Students

STILL LIFE

And a Bunch of Random Floating Guys

SketchUp Examples from Students



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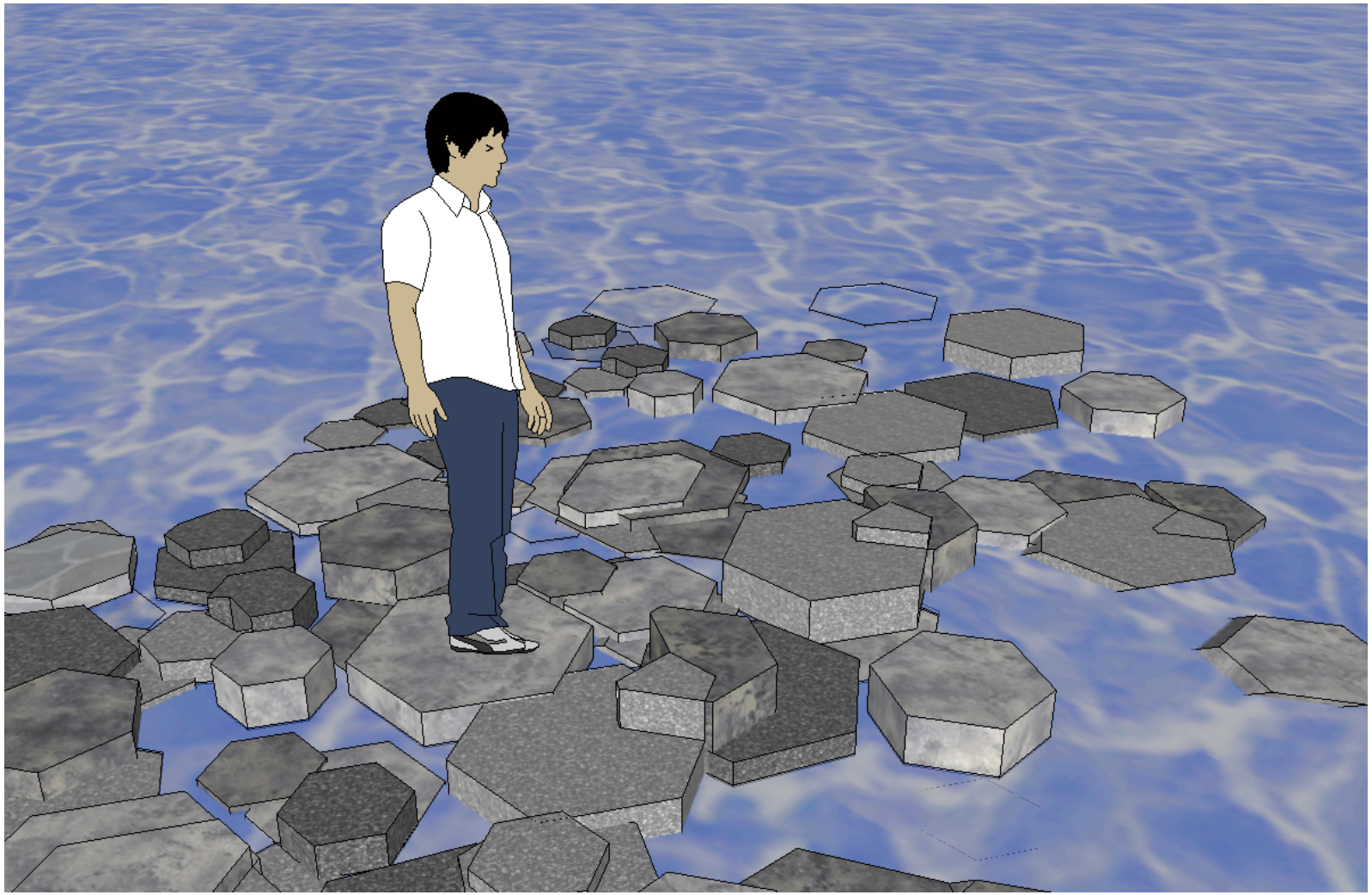
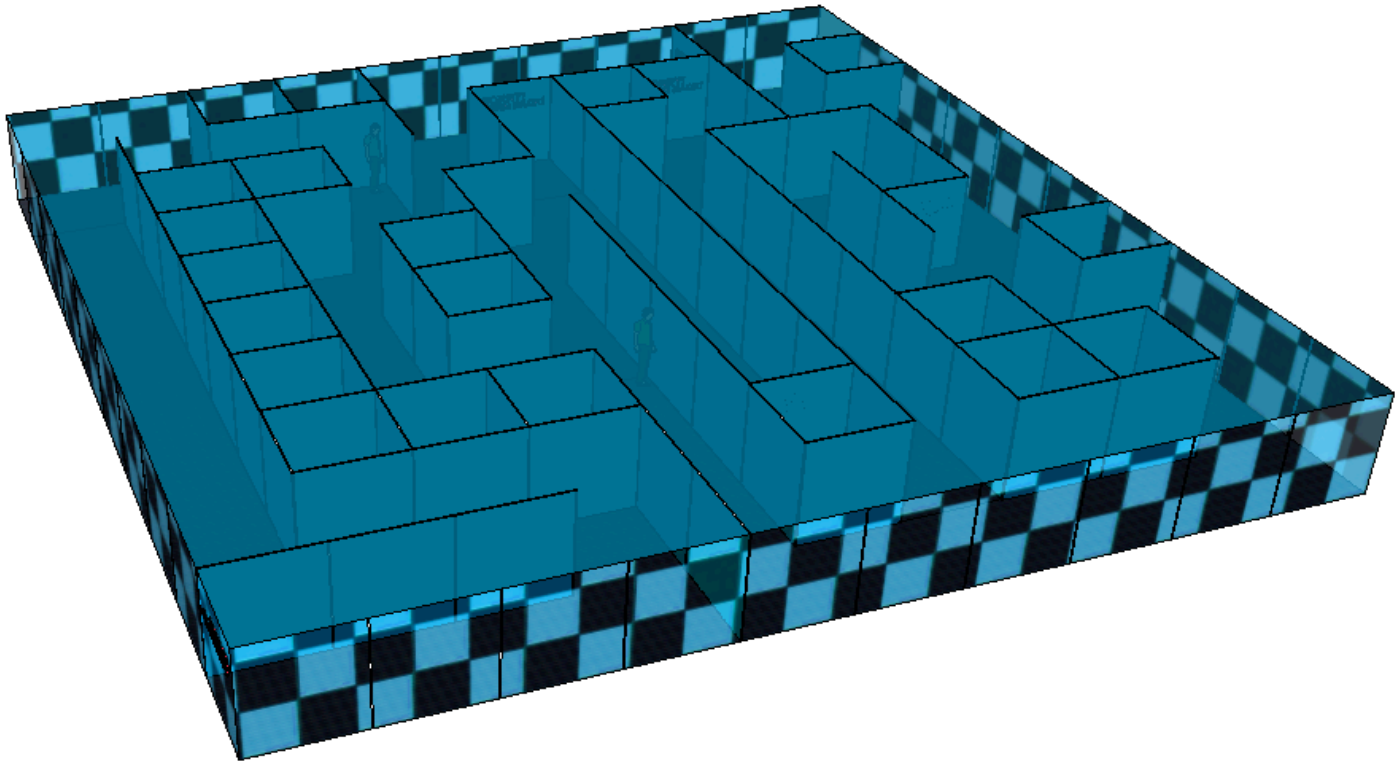


SketchUp Examples from Students

MAZE
Solution underneath

P.S. No cheating by walking through the walls!



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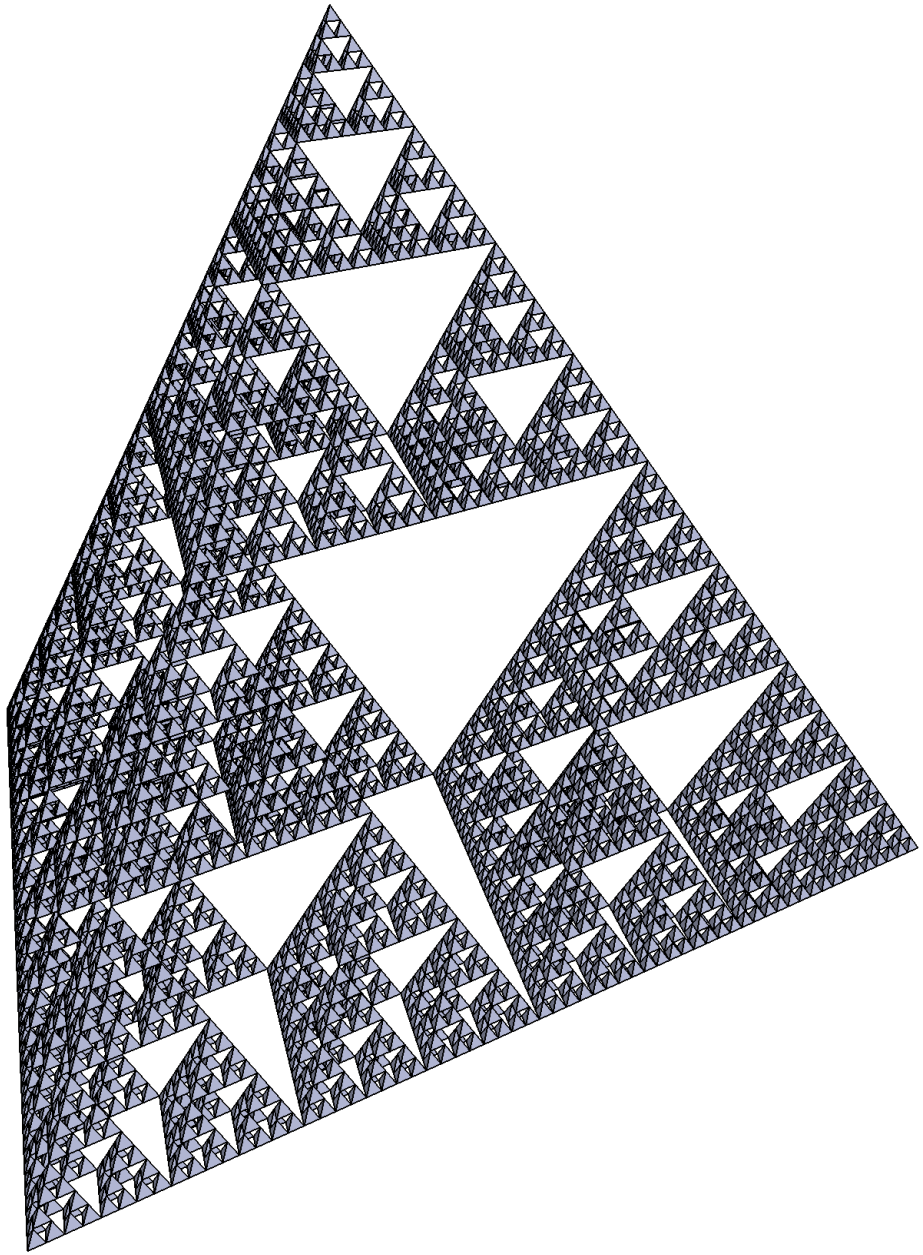

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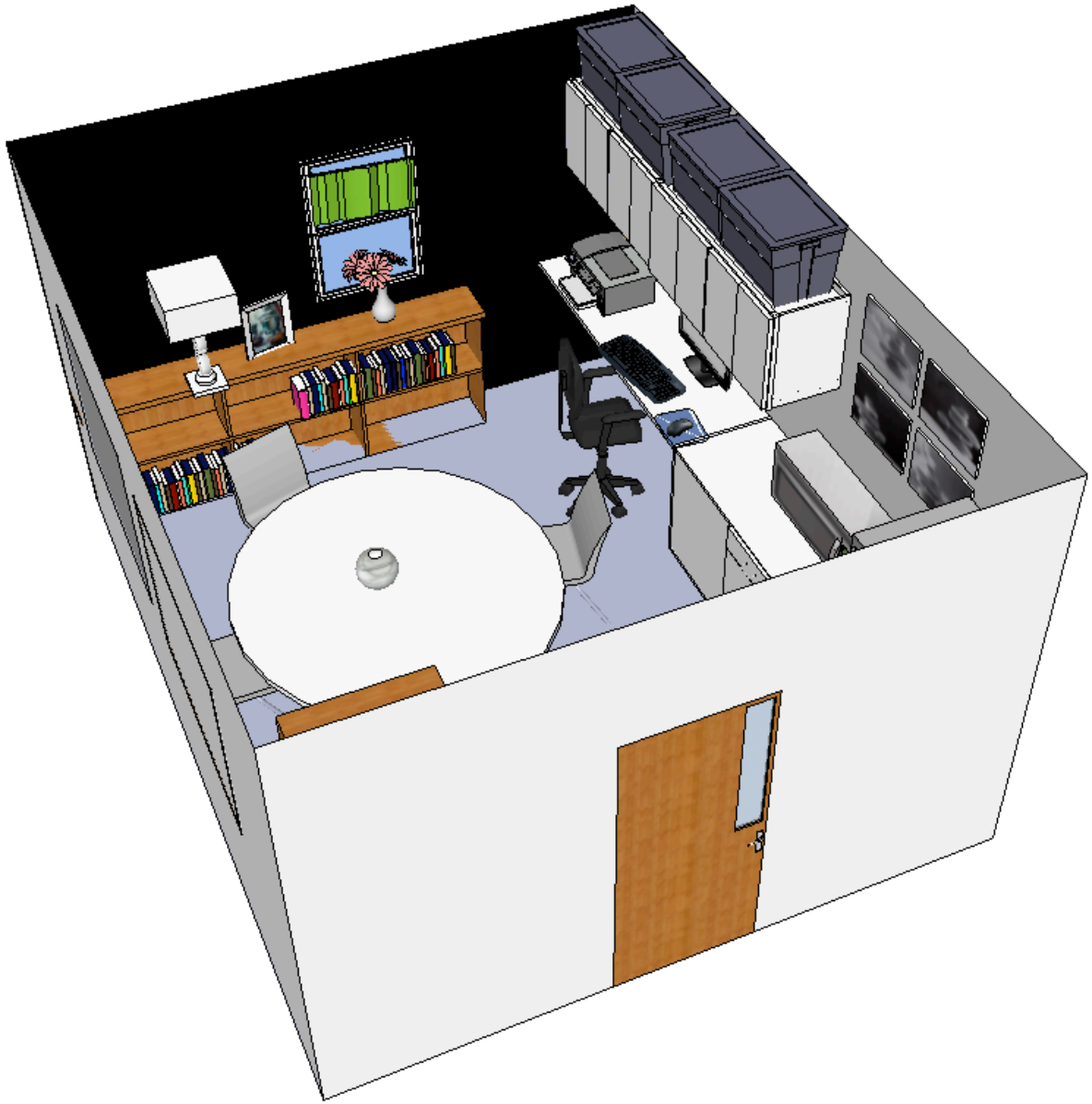

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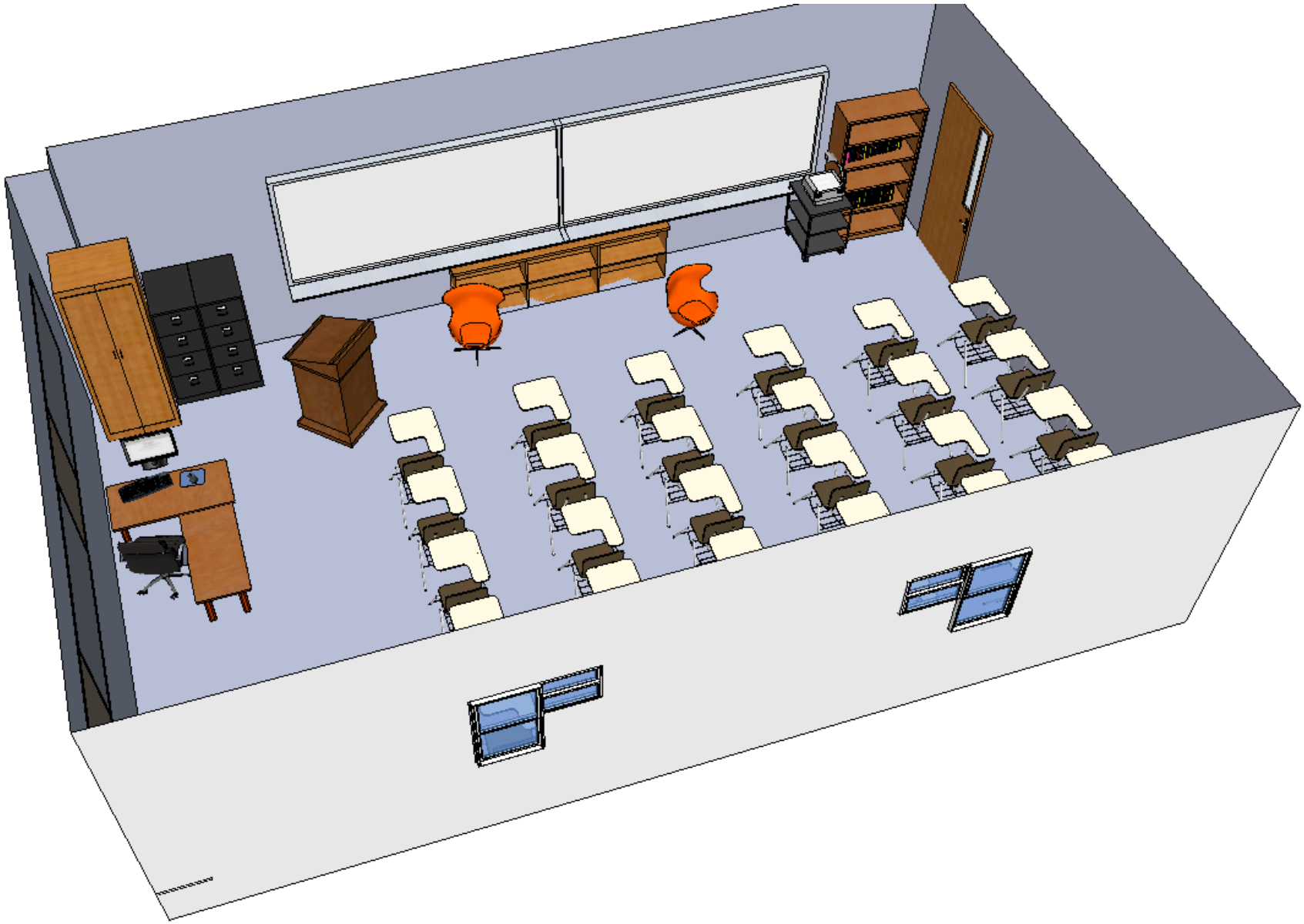

Student Feedback on Geometry Used

- One skill used was angle measures. When you had to rotate things, you had to know the angle measurement to get the object in the correct position. Another skill was scaling an object. You had to know proportions to scale the object correctly. One last skill you had to know was lines. You had to know things about lines in order to actually construct objects.
- When building our rooms, used measurments to place objects, using sliding, reflecting, and tessalating.
- In building Sierpinski's pyramid I had to use the pythagorean theorem, also when building the room I had to use my skills in measuring and scaling. And lastly, when I was putting objects in the room I had to use my knowledge on angles to have them in the right position.

Personal Observations

- Highlight for me: Student presentation at state meeting.
- (Most) students were actively engaged, working together, encouraging each other, and using mathematical language to describe the objects and actions they were engaged in.
- Such an activity requires appropropriate space for students to use the technology.
- The teacher needs to be comfortable with the software and be willing and able to respond flexibly to opportunities, questions, and ideas generated by the students.
- Students with computers at home can continue working on projects outside of class, as well as learn how to use various software features and teach the rest of the class
- Some schools are using SketchUp and such programs as Blender in design classes.

A Challenge

Students rapidly learned the software to carry out geometry modeling tasks.

What are some appropriate tasks or lessons for which this software might be well-suited?

Thank you!