

Building NumberOpolis!®

Concept for Teacher Guide, Student Facilitation, Work Pages, and Assessment Rubrics

7-lesson Program

Teacher Guide

Building NumberOpolis! entails the design and construction of an entire town with numbers 0-9, and/or higher-level math and science constants. This will require about 5-30 one-hour class periods depending on student age and extent of collaboration with other STEM/STEAM programs. The program enhances cognitive thinking and provides students with opportunities to think of mathematics as world patterns, linking it to all areas of life. In addition, the program integrates their imagination with nonstandard shapes—an important aspect of applying mathematics in future endeavors and careers.

Once teams are established, students can work together after school or at home, further deepening their understanding and family engagement. Building NumberOpolis! can easily integrate other single-disciplined STEM/STEAM programs.

An overall “urban plan” incorporating all created number houses and associated common areas, can be included in the first or second sessions. Depending on time restrictions, teachers, older students or an extra team may be needed to prepare the overall urban or country plan.

All lessons will be finalized to reflect the age and sophistication of the students while also considering time allotments. Even the youngest students can consider all of the lessons below. The grading can be made simpler or more complex to reflect the actual class. We will refine Lessons 1-7 to accommodate other STEM/STEAM programs and time allotment of formal and informal classroom time.

- Lesson 1: Discuss links of numbers to world patterns and shapes. Students complete application for number team (or let them set up teams more holistically). Establish group teams before the end of the lesson.
- Lesson 2: Discuss standard and nonstandard shapes, award-winning and standard architectural designs in the area and from around the world. Older students or G/T upper-elementary students can discuss thought-provoking questions, such as: Which shapes are more stable for building, doing string art, constructing clothing? Consider why a play would be titled, “Parallelogram? What is the impact of ϕ , the golden mean, in the natural world?
- Lesson 3: Discuss the design-thinking approach: What is the goal and how to reflect the selected number in design and interior decoration?

Each group must complete the design-thinking process and define the roles of each team member.

Lesson 4: Groups design their number home and write up their planned approach. This requires some research and printing of relevant items from various resources.

Lesson 5: Groups review and 2+ other designs. Teacher/parent and group reviews are provided to each individual group about their design.

The group considers and responds via design adjustment or reasons for not making an adjustment based on critiques.

Lesson 6: Construct and decorate the home.

As time permits, add accessories (car, home entrepreneur locations, gardens, bridges, bike/scooter paths, etc.).

Lesson 7: Teams provide a short (5-10 min) presentation on their design approach and place their home into the town.

The teacher, parent or other student will video the presentations and take photos of the individual houses and entire town.

Materials needed (nice task for parents to lead):

Recycled toner packing materials, coffee cup carriers, paper towel/toilet paper rolls, food carriers, etc.

Small pie tins, cotton balls, buttons, shells, yarn, fabric pieces, ribbons, small sticks, stickers, etc.

Cardboard

Paper glue, glue-guns, and colorful duct tape

Scissors, pens, straight edge, matt knives, etc.

For examples of pages that show links of numbers to patterns in the world, see attached powerpoint document, "Meet Team Ten Visually" created by Dr. Klemm.

Work Page: Job application

1. What number team do you want to be on? Why do you want to be on the team? Who else should be on the same team?
2. What role do you want on the team—team leader, team designer, team lead of construction, team public relations/communicator, team researcher? (Due to team size, some students will necessarily fill multiple positions.)
3. What are your qualifications for being in each desired role?
4. What skills do you have that should make you the person selected for the task?

Work Page: Describe the design-thinking process

1. Research number links using materials provided as well as other ideas and information researched.

2. Describe the overall design approach.
3. Provide references for each picture obtained from the web or other resources.

Work Page: Student plans

1. How to determine the shape of the house: base shape; number of floors; complexity of design (one main shape or a “compound-like” house); outside features; etc.
2. Budget (older students): assign prices to materials and labor and provide a budget for each team.
3. Determine construction materials and decorative items. (Include in budget or ignore due to time and extent of recycled materials.)

Work Page: Grading houses—internal team group score and external team group score

1. Score 5 points for each numeric link (starfish for 5): quantity; shape; name; or order. Add 5 extra points for each link not noticed by class reviewers.
2. Each numeric link can be reflected via drawings, pictures, sounds, games, objects, etc.
3. Add 25 point possible score for design-thinking write-up and 25 point possible score for oral presentation.

Work Page: Team grading sheet

1. Each member of a team grades themselves and every other member of the team.
2. Name each member of the team and rate in an easy manner (1-4 score is possible ratings):
 - a. Did the project work better because of this person? If not, why not? If yes, why?
 - b. Did the person listen, collaborate, give ideas?
 - c. Which team members were helpful or polite to the other team members?
 - d. What was the most difficult part of the project?
 - e. What lessons did you learn?
 - f. How would you do the project again for another house?
 - g. What was the most fun part of the project?
 - h. What was the most tedious part of the project?
 - i. Which team member (other than yourself) was the most valuable toward getting the project done on-time and of best quality?