Structures by Algorithm	Grade 5 Structures and Mechanisms

# Lesson Plan	Coding Tool	Algorithms
	Cross-curricular	Geometry, Procedural writing

Big Ideas

- We can measure forces in order to determine how they affect structures and mechanisms. This information can be used to guide the design of new structures and mechanisms.

  In nature, creatures like bees do not create structures based on a blueprint. They use naturally-evolved algorithms to guide them step-by-step through the building process. Human-built 3D-printers operate the same way.

Specific Expectations

2.4 Use technological problem-solving skills to design, build, and test a frame/structure that will withstand the application of an external force or a mechanical system that performs a specific function

2.6 Use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

Description

Students will create an algorithm, a step-by-step process, to draw or build a structure in the same way that Bees and 3D printers are guided by natural or computer-generated algorithms to create specific structures. This can be done in 2D on paper, or, optionally, expanded to three dimensions using 3D-doodler pens or another building tool.

Materials

- Protractors
- Rulers
- Pencils
- Paper
- Optional: "3D doodler" pens or other building tools.

Computational Thinking Skills

- Algorithmic thinking
- Loops

Introduction

- Introduce, or re-introduce, the idea of an algorithm: a series of instructions in the form of specific, concrete steps. (You can link this to procedural writing, if desired.)
- Discuss how algorithms can be used to create structures, using the example of bees (see resources) and 3D printers. You can challenge your students to think of other examples.

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Action

Work through first half of the Honeycomb Structure Algorithm handout with your students as an example. (Note, however, that bees do not actually follow this algorithm. It is now believed that bees create circular chambers that deform into hexagons.)

If desired, allow your students to attempt the challenge on the second half of the Honeycomb Structure Algorithm handout. One example of an algorithm that would allow them to fill more of the page is as follows:

1. *Place ruler flat on page, horizontally.*
2. *Holding your pencil, place it tip down on the page next to the ruler.*
3. **WHILE***: pencil and ruler are on page*
    I. *Draw 5cm straight line along ruler.*
    II. **FOR** *5 repeats*
        i. *Turn ruler clockwise 120 degrees*
        ii.*Draw 5cm straight line along ruler.*
    III. **FOR** *5 repeats*
        i. *Turn ruler counter clockwise 120 degrees*
        ii.*Draw 5cm straight line along ruler.*
4. *Place ruler along upper-left edge of honeycomb   (NOTE: this step occurs after the while loop, so should only occur after the pencil or ruler have gone off the page.)*
5. *Holding your pencil, place it tip down on the page next to the ruler.*
6. *Repeat from step 3.*

Have students create their own structure-drawing algorithms, and attempt to draw structures from them. Remind them to think of what forces might act on this hypothetical structure as they design their algorithms.

Consolidation/Extension

Have each student swap algorithms with a partner. Can their partner follow the student's algorithm to create the diagram of the structure?

OPTIONAL:
After drawing their algorithmic structures on paper, have students try creating them in real life using 3D-Doodler pens, or another, similar tool. Students can then test how their structures respond to different forces in an inquiry-based or teacher-guided way.

Assessment

Assess the coherence and detail of the students' algorithms. Students can also self-assess based on how well their partners are able to follow the structure-drawing algorithms.

If a physical structure is created, the structure can be assessed or self-assessed for how well it withstands various forces.

Additional Resources

Algorithm design:

"Algorithm Design and the Circulatory System" at https://education.sciencenorth.ca/grade-5/

https://www.tynker.com/blog/articles/ideas-and-tips/how-to-explain-algorithms-to-kids/

Algorithms in nature:

https://www.smithsonianmag.com/smart-news/stingless-bees-build-spiral-honeycombs-grow-crystals-180975405/

http://www.algorithmsinnature.org/

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