Lissajous: The Influence of Pi
Lesson Plan
Grade Level: 6 - 8
Time Required: One to two class periods.

Overview
This lesson teaches students about circles, π (pi), and the intersections of shapes in the natural world. Learning comes alive when students are given the chance to see mathematical concepts represented in dance and the very act of choreography. Students will begin the lesson studying circles in 3D; then, close watch a video about ***The Making of Lissajous***, the dance choreographed and performed by the Bowen McCauley Dance Company; and, finally, create their own spirograph.

Background for Teacher
In the winter of 2018, Drexel University commissioned Bowen McCauley Dance Company to produce a dance piece to explore the intersection of engineering mechanics and movement. The purpose of the commission was to demonstrate the science behind the creative process and the interconnectedness of Math, Engineering, and the Arts.

Two students and their engineering professor, Dr. Leslie Lamberson, visited our company in rehearsal to affix sensors to the dancers and collect real-time data on the visual elements of their movements. This data was shared with the choreographer, Lucy Bowen McCauley in real-time, as she developed the dance. The resulting dance piece, *Lissajous*, was set on eight Company dancers with an original music composition, *To Say Pi*, by Ph.D. music composer, Jordan Alexander Key. The piece premiered in December 2018 - Dance Place in Washington, DC.

Bowen McCauley Dance Company designed this lesson to inspire students to see the connection between STEM subjects and the arts – specifically dance. The activities will provide students with a deeper understanding of circles and π (pi) and encourage them to appreciate shapes, patterns, and movements that inform dance choreography.

Objective
Students will be able to explain the geometry of circles and recognize how shapes intersect in nature and art.

Essential Question
How do shapes and patterns appear in and influence art and, more specifically, dance?

Key Vocabulary
accelerometer, choreography, commission, frequency, lissajous, rotational motion, rotational symmetry, sensor, sinusoidal, symmetry

Materials

- Yarn or string (about 50 feet)
- Yard stick or tape measure
- Video clip Lissajous Doc. featuring Bowen McCauley Dance Company
- Copies of articles: See a Data-Driven Contemporary Dance, CoE Engineers Inspire Dance Project Bound for Kennedy Center
- Paper
- Corrugated cardboard (enough for every student to have a piece about the size of a piece of paper)
- Compass
- Scissors
- Glue
- Pens, pencils, and/or colored pencils

Hook

Human Circle: Students create circles, take measurements, and analyze the results.

1. Break students into groups of 8-10 (or do this activity as a whole class, if you prefer).
2. Assign two students to take and record measurements for each group; the rest of the students will be standing in circles of various sizes.
3. Have each group of students stand in as perfect a circle as possible. Have the students taking and recording measurements use the yarn/string and yard stick/tape measure to measure the circumference, diameter, and radius of the circle created by the standing students.
4. Repeat this process two more times, encouraging the standing students to spread out and squeeze in to change the parameters of the circle, based on how far apart they stand from each other (e.g., arms spread out, loosely shoulder to shoulder, squeezed in as close as possible).
5. With the measurements in hand, have the groups analyze the relationships of the measurements. You may prompt them with questions such as *Do all the numbers change? Do they change the same way? The same amount? Can you make any definitive statements about measurements in circles from your data?*
6. Discuss π (pi) and how it relates to the measurements your students analyzed. Point out that, while the parameters of a circle may change, some mathematic relationships are constant.

Lesson Activity 1: Patterns in Movement

1. Watch the video "Making of Lissajous" documentary – see the development in action. Have students watch without taking notes or responding.
2. When the video is over have them talk about which role in the process is most appealing or interesting to them (i.e., would they like to be the data collection person, a dancer, or the choreographer). Ask them to reflect on the reason(s) for their answer.
3. Distribute the articles: *See a Data-Driven Contemporary Dance* and *CoE Engineers Inspire Dance Project Bound for Kennedy Center*, and *Mechanics of Dance* slide presentation (PDF).

4. Use the Jigsaw strategy to have students in small groups read and discuss the articles. In a Jigsaw, students start in a base group that has all the articles from which each student chooses one. Then, students leave their base group for a group of students that all picked the same article. In that article-specific group, they closely read the article and make sure everyone in the group has a good understanding of the content. Then, students return to their base group to share information and make sure everyone understands all the articles.

Lesson Activity 2: Creating Your Own Pattern Through Movement (The Spirograph)

1. [Although your students may be familiar with spirographs, proceed with this activity without describing, looking at pictures, or watching videos of a spirograph.]
2. Distribute the corrugated cardboard, scissors, and directions for making a spirograph. (You may want to pre-cut frames, circles, and strips of cardboard for the teeth in advance.) Allow students to create their spirographs.
3. Allow students to play with their own spirographs and to try out their classmates' spirographs. This should be a loud, disorganized period of discovery as they watch patterns emerge.
4. Finish up the spirograph activity by encouraging students to color their spirograph image to highlight the patterns that emerged.

Assessment

Students will complete a Venn diagram to explore the intersection of 1) math and dance, 2) engineering and movement, or 3) science and art.

Differentiation

- Assign students specific roles for the group activities, according to interests and abilities.
- Allow students to work individually and/or with concrete objects to conceptualize the material.
- Provide a partially completed Venn diagram, with all areas started or one or more areas complete.

Standards Addressed: Virginia Standards of Learning

Grade Six: Measurement and Geometry

6.7.a The student will derive π (pi)

6.7.b The student will solve problems, including practical problems, involving circumference and area of a circle;

Grade Seven: Patterns, Functions, and Algebra

7.10.e The student will make connections between and among representations of a proportional or additive relationship between two quantities using verbal descriptions, tables, equations, and graphs.

Grade Eight: Patterns, Functions, and Algebra

8.16.e The student will make connections between and among representations of a linear function using descriptions, tables, equations, and graphs.

Referenced Video Links and Articles (https://www.bmdc.org/outreach/educational-curriculum)

Making of Lissajous documentary (2 mins.): [https://vimeo.com/358364538]

- ***Data-Driven Contemporary Dance*** **article**: [https://www.stayarlington.com/blog/see-a-data-driven-contemporary-dance/]

- ***CoE Engineers Inspire Dance Project Bound for Kennedy Center*** **article:** [https://drexel.edu/engineering/news-events/news/archive/2019/April/coe-engineers-inspire-dance-project-bound-for-kennedy-center/]