LESSONS 9–13: Investigating Community Needs, Designing Outdoor Spaces

PREPARATION

Learning Goals
• I can move through the stages of the modeling cycle to define, design, and justify a solution to a real problem. • I can design and analyze a survey to understand the needs and perspectives of a specific community. • I can apply geometric methods and reasoning, including area, volume, and circle equations, to solve a design problem related to public spaces.
Content Language Objective
I can justify my design decisions based on community needs and geometric reasoning using justification language. [orally and in writing] **[Presentational]**

Justification language:	Terms and notations:
• Given the constraint of _____ , _____ was the best option because _____ . • The data showed _____ , which led us to _____ . • This decision helps ensure that _____ can _____ . • _____% of respondents said _____ , so we included _____ .	• Synthetic data • User profile • Capacity • Cross section

LESSON NARRATIVE

This is a five-day Investigation Lesson that spans 250 minutes. The purpose of this five-day lesson is to engage students in the full modeling cycle, with support, as they design an outdoor space responsive to the needs of a given community. Students begin by examining how geometric modeling and statistics work together in authentic design contexts in Part One.

TEACHER REFLECTION

How will you prepare yourself to support students in persevering through the ambiguity and revision central to this lesson without removing the challenge? (***High Expectations***)

In Part Two, students investigate the needs of a chosen community, represented by a ***user profile,*** through developing surveys intended to elicit actionable design input. Students reason about sampling, representation, and the ways survey design can shape conclusions. They also revisit distinctions between qualitative and quantitative data, first explored in Module 1. They analyze AI-generated survey responses to identify patterns, gaps in representation, and implications for design decisions, and they reflect on the benefits and implications of generating **synthetic data** (*MSP: Sensemaking*). This work positions students to model with mathematics and statistics by using data to clarify the problem they are solving. Students also critique the adequacy of data and consider whose perspectives may be excluded, reinforcing that mathematical and statistical models are shaped by assumptions and limitations.

In Lesson 1, students articulate why a coordinate grid can be a helpful tool for communicating a specific location in a space. In Part Three, students have the opportunity to build on that understanding with their own agency to strategically choose where to place the origin in relation to their blueprint template. Students incorporate community priorities into a geometric blueprint by designing within spatial constraints and justifying decisions through calculation and reasoning. Students apply geometric concepts such as perimeter, area, volume, surface area, ***capacity***, and equations of circles to determine how spaces function for intended users. As students test dimensions, compare alternatives, and revise layouts, they engage in iterative modeling by moving repeatedly between calculations and contextual interpretation (*MSP: Model; Contextualize*). Students strategically select

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tools and representations while considering the affordances and limitations of each (*MSP: Tools*). Within groups, students contribute ideas, critique reasoning, and refine designs collectively (*MSP: Collaborate*).

In Parts Four and Five, students prepare a public-facing design showcase that includes reflections about the final design and the overall process before participating in peer critique. Students communicate mathematical and statistical reasoning precisely as they justify how design decisions respond to survey findings, accessibility considerations, density constraints, and geometric calculations (*MSP: Tinker; Precision; Communicate*). Through gallery walk interactions, students compare strategies, evaluate assumptions, and recognize that multiple valid models may emerge from the same design challenge when supported by evidence and reasoning. The lesson culminates with students reflecting on how mathematical modeling can be used to advocate for communities and design spaces that are more functional, inclusive, and responsive to human needs.

A custom chatbot must be created prior to this lesson to create synthetic community survey data in Part Two. Reference the *DPS Handbook on AI Use in Schools* for guidance on appropriately integrating AI for use in the classroom. Students review the chatbot instructions to better understand how to build or leverage such an AI tool for these purposes.

Big Idea
The big idea of this lesson is that responsive designers use data, geometry, and contextual reasoning to design solutions that respond to the needs of real communities.

FOCUS AND COHERENCE

Building On	Addressing
• **HS.9.1:** Classify data that arises from a context as univariate or bivariate and classify whether the variable(s) associated with a set of data are categorical or quantitative (discrete or continuous) • **HS.9.2:** Create visualizations to organize data according to its classification, using appropriate technology. Visualizations must include pie charts, side-by-side boxplots, histograms, stem plots, two-way frequency tables, scatterplots, and segmented bar graphs. • **HS.9.3:** Summarize the characteristics of a data display in context, using technology to calculate appropriate summary statistics that describe the data set. • **HS.9.5:** Critique data-based claims and visualizations for potential misleading features, ethical implications, and limitations. • **HS.19.1:** Write the equation of a circle in standard form using the center of the circle and the radius. May use technology to graph and identify the center of a circle and/or radius using the distance formula or Pythagorean Theorem, solving simple cases by hand and more complicated cases with technology. • **HS.19.3:** Solve tasks in authentic contexts using perimeter and area of triangles, parallelograms, trapezoids, regular polygons, and circles. • **HS.19.4:** Solve tasks in authentic contexts using surface area and volume of cylinders, pyramids, cones, and spheres. • **HS.19.6:** Identify the shapes of two-dimensional cross-sections of three-dimensional objects and visualize solids generated by rotating two-dimensional figures using physical models or technology. • **HS.19.7:** Use geometric shapes, their measures, and their properties to describe real-world objects, and solve related authentic modeling tasks.	• **MSP: Model:** Modeling with mathematics and statistics. • **MSP: Tools:** Use appropriate tools, including technology, strategically. • **HS.9.4:** Justify data-based conclusions about one or two sets of data, using a display or summary statistics as evidence. • **HS.9.11:** Justify data-based conclusions about multiple sets of data using a display or summary statistics as evidence. • **HS.12.2:** Articulate what constitutes good practice in designing a sample survey, an experiment, and an observational study. • **HS.12.5:** Describe the role of randomization in relation to the scope and validity of statistical inferences. • **HS.13.2:** Explain how bias may occur in sampling, yielding results that are not representative of the population of interest. • **HS.13.4:** Explain that the purpose of randomly selecting subjects from populations is to make the samples as similar to the population as possible.

LESSON AT A GLANCE (250 minutes)

LAUNCH

Part One (20 minutes)

Purpose: Introduce the scope of the design project and its connection to the modeling cycle

Routine(s): Visibly Random Grouping; Round Robin

Materials: Blueprint Templates (choose printed and/or digital Desmos or Tinkercad blueprint templates)
- "Paper Blueprint Templates" (print enough copies so that each group assigned a template has access to several copies for iterative process)
  - "Paper Blueprint Templates with coordinate plane axes–Responsive Strategy" (as needed, print enough copies so that each group assigned a template has access to several copies for iterative process)
- "Desmos Geometry/Tinkercad Blueprint Templates" (Tinkercad class instructions and student log in instructions included as needed)

EXPLORE

Part Two (50 minutes)

Purpose: Develop a survey to elicit community needs about a chosen community space and analyze results to inform design decisions

Routine(s): Notice and Wonder; Critique, Correct, Clarify (MLR3) – Responsive Strategy; Discussion Supports (MLR8) – Responsive Strategy

Materials:
- Internet-enabled device. (It is ideal if each student has their own device.)
- "Community Space Profiles": https://bit.ly/M3M4L9-13profiles
- "MagicSchool Community Survey Chatbot instructions" (develop custom AI chatbot in advance to share with students during class)
- "Student Community Survey Chatbot instructions" (display)
- "Common Survey Question Frames–Responsive Strategy" (optional and as needed)

Part Three (95 minutes)

Purpose: Design a scaled outdoor space on an assigned blueprint for a specific community's needs and perform related geometric calculations

Routine(s): Discussion Supports (MLR8) - Responsive Strategy

Materials:
- Blueprint Templates (paper or digital) from Part One
- Markers/colored pencils (multiple per group)

Part Four (45 minutes)

Purpose: Prepare the showcase presentation, including a self-assessment reflection

Materials:
- Blank visual displays for each student group (possible visual display options: Google Slides, non-permanent vertical whitespace, poster board, chart or butcher paper)
- Markers (multiple per group)

Part Five (30 minutes)

Purpose: Offer and receive peer feedback on design projects and reflect on the full modeling cycle experience

Routine(s): Discussion Supports (MLR8) - Responsive Strategy

Materials: 3 different-colored sticky notes (several of each color per student)

SUMMARIZE

Wrap-Up (10 minutes)

Purpose: Process the full modeling cycle experience

Routine(s): Circle Up!; Discussion Supports (MLR8) - Responsive Strategy

Materials:
- Previously created display of Circle Up! norms
- Restorative Circle Piece (a small token such as a marker, ruler, class mascot, etc.)
- Student Reflection Question (choice method for submission)

LAUNCH

PART ONE: Lay of the Land (20 minutes)

Instructional Routines: Visibly Random Grouping; Round Robin
Addressing: MSP: Model

In Part One, students are introduced to the full scope of the Investigation Lesson and begin to see the modeling cycle as the structure that will guide their work across the next several days. They map each part of the multi-day lesson to stages of the modeling cycle, building a shared understanding that modeling is not a one-time process but an iterative cycle (*MSP: Model*).



Step 1

- Use *Visibly Random Grouping* or another strategic grouping technique to arrange students in groups of three. **Students will stay in these groups for the remainder of the lesson.**
- Introduce the multi-day Investigation Lesson by telling students that they will be engaging in the full mathematical modeling cycle by designing an outdoor space to meet the needs of a chosen community.
- Provide students 4 minutes to complete question 1 independently.
- Facilitate the *Round Robin* routine by providing groups with an additional 8 minutes to discuss their responses to question 1 and reaching a group consensus.

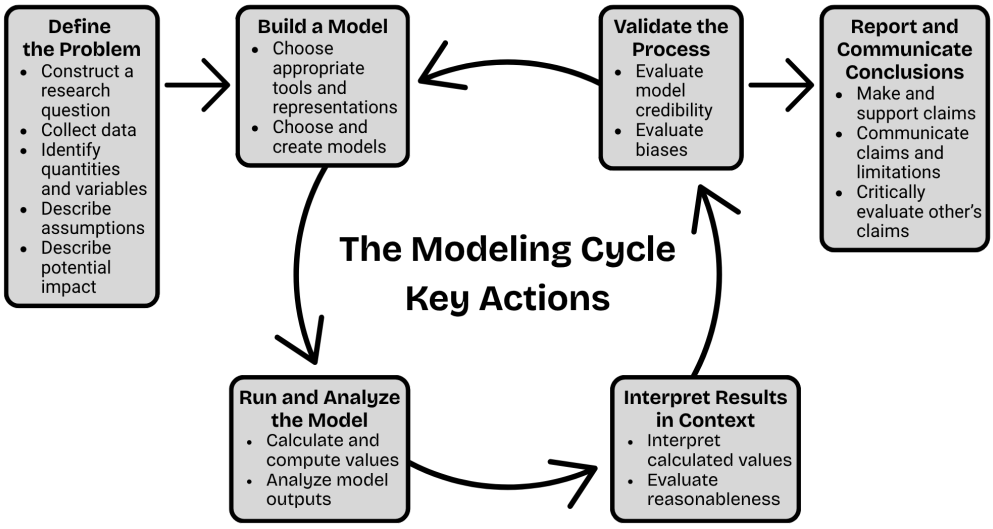
RESPONSIVE STRATEGY

Display the task and invite students to read aloud with a partner. Invite students to discuss their initial thoughts on the summary of actions for each part of the task with their partner before moving on. Suggest that students annotate each action to elevate key information and clarify language. Check for understanding by inviting students to rephrase the summary of actions in their own words. (***Supports accessibility for: Language***)

ROUND ROBIN 	***What Is This Routine?*** In small groups, students take turns sharing their rough draft response to an open-ended question while other group members refrain from comments or questions. A prop can be passed within each group to indicate whose turn it is to talk. After each student has had a turn to share, the group can ask questions of each other; then, the teacher selects students to share with the whole class what their group members said. ***Why This Routine?*** Engaging a group of students in collaborative problem-solving, with equitable inclusion of ideas, can be challenging due to normative social status issues that place higher value on some students' contributions over others. *Round Robin* allows all students to include their rough draft ideas for solving an open-ended question without a subset of students dominating the conversation. Knowing all ideas will be shared should motivate all students to try at least one strategy to solve a problem on their own, which is critical for making sense of problems and persevering in solving them. The active sharing and listening involved in this routine also provides opportunity for constructing and critiquing viable arguments.

Student Task Statement

The table names numerous actions that you and your group will engage in as you investigate community needs for an outdoor space and design with those needs in mind. Review the "Summary of actions" for each part of the lesson and determine which stage(s) of the modeling cycle occurs in that part of the lesson.



Summary of actions	Stage(s) of the modeling cycle
Part Two • Select an outdoor space type and corresponding community profile. • Develop a survey community members will take to provide input for design decisions. • Use AI to generate survey responses reflective of the community. • Analyze survey results.	
Part Three • Select from a variety of tools to design a blueprint based on a required list of elements and community priorities. • Perform calculations associated with blueprint design.	
Part Four • Reflect on the design process and how well the design addresses community priorities. • Prepare a design showcase that justifies decisions made in the design.	
Part Five • Engage in a showcase gallery walk to provide feedback on others' designs and justifications.	