TOP | TRANSATLANTIC OUTREACH PROGRAM

STEM

CITY LAYOUTS & SUSTAINABILITY

Exploring Karlsruhe Through Proportional Relationships

Middle School

City Layouts and Sustainability: Exploring Karlsruhe Through Proportional Relationships

Next Generation Science Standards (NGSS)	**NC.7.RP.2 Recognize and represent proportional relationships between quantities.**
Materials Needed	See below
Phenomenon	
Engage	Begin by showing aerial imagery or map and sustainability facts about Karlsruhe. Students will be asked direct questions. Students brainstorm and ask questions about city layout decisions.
Explore	In pairs, students analyze Karlsruhe's layout using simplified two-quantity ratio-based data cards.
Featured Sources	
Featured Sources	• German Federal Environment Agency. (2022). Sustainable Urban Development Reports. https://www.umweltbundesamt.de/ • Karlsruhe Institute of Technology. (2021). Sustainable Urban Design and Mobility. https://www.kit.edu/ • KIT Department of Urban Planning. (2023). Pedestrian and Transport Infrastructure Research Briefs. Karlsruhe Institute of Technology. • Karlsruhe Open Data Portal. (2023). Stadt Karlsruhe Transparenzportal. https://transparenz.karlsruhe.de/ • OpenStreetMap Contributors. (2023). Karlsruhe Urban Infrastructure Mapping. https://www.openstreetmap.org/ • Statista. (2023). Renewable Energy and Resource Management in German Cities. https://www.statista.com/ • Statista. (2023). Urban Sustainability Statistics in Germany. https://www.statista.com/ · Weller, R. (2019). Planning Green Cities: Sustainability and Urban Form. Urban Studies Journal, 56(8), 1562–1580.
Explain	Students generate written and verbal explanations. Students may explain how proportionality simplifies communication in planning and helps scale policies to different cities.
Create a Prototype	In small groups, students will research the engineering design process and its role in creating sustainable solutions. Then, they will design a sustainable urban solution for a hypothetical city, incorporating proportional reasoning. Students will create a drawing and scale model of their proposed solution. Each group will present their sustainable urban solution to the class. The class will provide feedback and ask questions about the proportional aspects of each design.
Elaborate	*Understand*: Students explore local city planning/zoning issues *Assess*: Evaluate the equity and sustainability of their town's layout *Act*: Design a campaign, write a letter, or present proposals to improve land use locally
Evaluate	Written Reflection: Students explain proportional reasoning in green urban development's success. Exit Ticket: Assess proportional relationship recognition based on another city's transformation. Summative Test (Unit Test) on proportional relationship

Phenomenon

City Layouts and Sustainability: Exploring Karlsruhe Through Proportional Relationships

Target Grade Level: 7	Target Course: Mathematics, STEM

Inquiry Overview

In this lesson, students will recognize and represent proportional relationships using tables, graphs, and equations to solve real-world problems. They will apply proportional reasoning to explore the impact of Karlsruhe, Germany's sustainable urban planning, including its layout, land use, and transportation systems. Integrating the 5Es Inquiry model and an engineering design challenge, the lesson connects mathematics, sustainability, and practical problem-solving. Students will engage with maps and data from Karlsruhe, analyze city zone ratios, and use their findings to design a sustainable city of their own. Learning will be assessed through formative checks, summative tasks, and presentations.

Teacher Background Information

Karlsruhe is a model for sustainable urban planning in Germany. Its fan-shaped layout, integration of efficient public transportation systems, green spaces, and renewable energy efforts make it ideal for exploring real-world math applications. This lesson supports cross-curricular links with science, geography, and engineering while grounding proportional reasoning in practical, meaningful experiences.

Sustainability in Karlsruhe

Karlsruhe has evolved into a leader in sustainable urban development, balancing growth with environmental stewardship. Key initiatives include:

1. Extensive Tram and Public Transport Network:
    a. The city is famous for its tram-train system, which allows seamless travel within the city and surrounding areas.
    b. Public transport reduces carbon emissions and traffic congestion.
    c. Math Connection: Proportions can help analyze the efficiency of transportation, such as calculating average distances between stops.
2. Bike-Friendly Infrastructure:
    a. Over 400 km of bike paths encourage eco-friendly transportation.
    b. Math Connection: Proportional relationships can be used to compare bike path lengths to street lengths or total city area.
3. Green Spaces and Parks:
    a. Green areas like the Schlossgarten (Palace Garden) enhance air quality and biodiversity.
    b. Math Connection: Analyze the proportion of green spaces relative to urbanized areas to highlight sustainable land use.

Suggested Time Frame

10 days (60 minutes per day)

Concept List

- Ratio and rates
- Proportional Relationship
- Tables, graphs, and equations
- Constant of Proportionality
- Scale and measurement
- Sustainability principles
- Urban zoning

Materials Needed

The project requires basic classroom supplies (e.g. paper, rulers, markers, colored pencils, glue), as well as instructional materials such as worksheets, data cards, and city maps. In addition, digital tools (e.g. computers or tablets, calculators, and internet access) may be used. For the final presentation phase, poster boards or presentation software can be utilized.

Featured Sources

- German Federal Environment Agency. (2022). Sustainable Urban Development Reports. https://www.umweltbundesamt.de/
- Karlsruhe Institute of Technology. (2021). Sustainable Urban Design and Mobility. https://www.kit.edu/
- KIT Department of Urban Planning. (2023). Pedestrian and Transport Infrastructure Research Briefs. Karlsruhe Institute of Technology.
- Karlsruhe Open Data Portal. (2023). Stadt Karlsruhe Transparenzportal. https://transparenz.karlsruhe.de/
- OpenStreetMap Contributors. (2023). Karlsruhe Urban Infrastructure Mapping. https://www.openstreetmap.org/
- Statista. (2023). Renewable Energy and Resource Management in German Cities. https://www.statista.com/
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Next Generation Science Standards (NGSS) / State Content Area Standards

NC.7.RP.2 Recognize and represent proportional relationships between quantities.

Outcomes for Student Learning

- Students will identify and model proportional relationships using tables, graphs, and equations.
- Students will recognize and represent proportional relationships in the context of Karlsruhe's urban development approach data.
- Students will apply proportional reasoning to assess the success of Karlsruhe's initiatives.
- Students will relate math skills to real-world scenarios, making connections between math and contemporary issues.
- Students will create and justify scaled layout models representing sustainable cities.
- Students will engage in an engineering design activity to propose and evaluate a sustainable urban solution, incorporating proportional thinking.

Germany-Related Learning Goals

- Understand the sustainable urban planning strategies of Karlsruhe
- Apply German-inspired sustainability strategies to their local communities
- Explore Germany's commitment to sustainability

Phenomenon / Main Problem

How does proportional reasoning support sustainable urban planning in Karlsruhe, Germany?

Engage

Begin by showing aerial imagery or map (Example: virtual tour using Google Earth, highlighting its fan-shaped layout) and sustainability facts about Karlsruhe. Ask students the following questions:

- What makes a city livable and sustainable?
- How might proportional relationships be used to design efficient cities?
- How do cities decide how much space should go to housing, transport, or parks?

Students brainstorm and ask questions about city layout decisions.

Note: Students may also have a quick Kahoot/Quizizz (any math game) on ratios to review.

Anticipated Guiding Questions

- What makes a relationship proportional?
- How do we find the constant of proportionality in data?
- How are sustainability and city planning connected?
- What are examples of proportional relationships in city planning?
- How do scales and ratios help us understand urban layouts?
- How can we represent real-world data in tables, graphs, and equations?

Explore

- In pairs, students will explore how city design and sustainability are connected by analyzing proportional relationships in Karlsruhe, Germany using simplified two-quantity ratio-based data cards. Please see Explore Handout for example cards and information (both teacher and student).

Featured Sources

- German Federal Environment Agency. (2022). Sustainable Urban Development Reports. https://www.umweltbundesamt.de/
- Karlsruhe Institute of Technology. (2021). Sustainable Urban Design and Mobility. https://www.kit.edu/
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Explain

Students generate written and verbal explanations:

- What proportional relationships they found in Karlsruhe's layout
- Why such relationships matter for sustainability
- Multiple interpretations of efficiency and equity in zoning

Example answers include: ·

- Card A Explanation: The ratio 40:25 (or 8:5) helps planners understand how much residential area is developed for every green space unit. This balance supports environmental health while meeting housing demands.
- Card B Explanation: The 3:2 tram-to-bike ratio shows transportation diversity and sustainability. This proportionality can help planners provide multiple eco-friendly travel options.
- Card C Explanation: A 4:1 green-to-residential block ratio prioritizes green space, which improves air quality and urban climate resilience.
- Card D Explanation: The 0.75:3 (or 1:4) garden-to-residential ratio indicates how cities can incorporate urban agriculture, which boosts food access and community wellbeing.
- Card E Explanation: With 1 station per 4 zones (1:4), city planners ensure energy access is distributed fairly and efficiently.

Overall, these proportional relationships reflect sustainable decisions in land use and resource allocation. Students may explain how proportionality simplifies communication in planning and helps scale policies to different cities.

Create a Prototype

In small groups, students will research the engineering design process and its role in creating sustainable solutions. Then, they will design a sustainable urban solution for a hypothetical city, incorporating proportional reasoning. Students will create a drawing and scale model of their proposed solution, considering proportional aspects like land use, energy consumption, and green spaces. They may use concrete materials (e.g., recycled cardboard, paper, building blocks) to build their scale model. Each group will present their sustainable urban solution to the class, highlighting the proportional considerations in their design. The class will provide feedback and ask questions about the proportional aspects of each design. They will also discuss the importance of proportional reasoning in evaluating and implementing sustainable urban solutions.

Students apply what they've learned to create their own scaled sustainable city layout. Their prototypes will:
·Include proportional zones (residential, green space, transport, etc.)
·Be represented via table, graph, and equation
·Include a written rationale of design choices

Materials: planning sheet, ruler, colored pencil, cardboard, tape/glue, markers, presentation board, computer or tablet

Student Instructions and Rubric can be found in the Prototype Handout

Elaborate

Understand: Students explore local city planning/zoning issues
Assess: Evaluate the equity and sustainability of their town’s layout
Act: Design a campaign, write a letter, or present proposals to improve land use locally.

Evaluate

1. Formative assessments in class discussions and practice: Check proportional relationship recognition.
2. Formative assessments in class discussions and practice: Check clarity and correctness in table, graph, and equation use
3. Engineering Design Evaluation: Assess output using a rubric.
4. Written Reflection: Students explain proportional reasoning in green urban development's success.
5. Exit Ticket: Assess proportional relationship recognition based on another city's transformation.
6. Summative Test (Unit Test) on proportional relationship

Virtual Exchange

- Connect with a class in Karlsruhe via video call to discuss sustainability goals, projects,
- challenges and exchange ideas about urban planning.

Career Connection Exploration

Essay / Presentation	Invite a city planner or engineer to speak about using mathematics in urban development and sustainability projects.

Modifications for Differentiation

- Provide scaffolds such as guided notes and step-by-step instructions.
- Offer advanced tasks for accelerated learners, such as analyzing economic data
- related to tram system costs.
- EL supports: sentence starters, visual vocabulary cards
- Use visual (color-coded materials) or hands-on manipulatives for students
- needing additional support.

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