Engineering Cleaner Air in K12 Classrooms: Lesson plans for engineering design, building, and testing air purifiers (Resource Exchange)

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Dr. Kristina Wagstrom is an Associate Professor in the Chemical and Biomolecular Engineering at the University of Connecticut in Storrs, CT. She specializes in applying chemical engineering principles to investigations of the impacts of air pollution on human and ecosystem health. She also spends time implementing novel, research-based pedagogy into chemical engineering undergraduate education and working extensively with undergraduate researchers from across disciplines.

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INDOOR AIR QUALITY INITIATIVE

Engineering Cleaner Air in K12 Classrooms

Lesson Series

- NGSS-aligned (ETS1 & multiple SEPs)
- Grades K-2, 3-5, 6-8, and 9-12
- Connect engineering to public health
- Low-cost, readily-available materials

Contact Us

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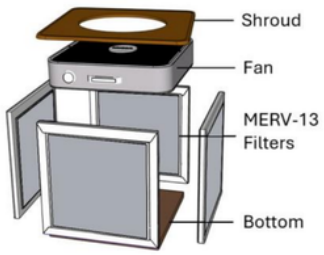
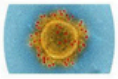


Four 1-hour lessons per grade band to increase awareness and improve air quality

Lesson Topic	NGSS connections	Description
Introduction to indoor air quality	Defining a problem	Multi-media introduction to air quality and particulate matter
Building the air purifier	Planning an investigation	Investigate air movement and optimize design
Collecting and analyzing data	Analyzing and interpreting data	Interpret data to determine changes in air quality
Sharing the results	Communicating technical info	Sharing findings with relevant stakeholders

They'll learn about  **germs and health,**  **engineering,**  **air quality — they'll even learn about**  **each other.**

Engineering Cleaner Air in K12 Classrooms:

Lessons for engineering, building, and testing air purifiers

This lesson series is meant to compliment the building and implementation of Do-It-Yourself air purifiers. The lessons introduce indoor air quality and focus on the Science and Engineering Practices (SEPs) such as defining problems, analyzing data, and communicating technical information. The lessons can stand on their own or be adapted to supplement curricular units.

Background Information

Indoor air quality matters, because we spend about 90% of our time indoors. Things in the air such as particulate matter (PM) and airborne viruses such as COVID-19 can have negative impacts on human health, especially for younger people whose respiratory systems are still developing and older people who often spend even more time indoors. Many factors influence indoor air quality, including temperature and relative humidity. Indoor air quality includes pollution from outside such as wildfire smoke, emissions from vehicles, and ozone.

More information can be found at EPA Indoor Air Quality in Schools

While commercial air purifiers exist, a DIY air purifier can be built using inexpensive materials, including a box fan, four MERV filters, cardboard, and duct tape. The fan pulls air through four standard HVAC filters that catch airborne pollutants. The DIY air purifiers reduce the amount of particulate matter and airborne viral particles. Design criteria for an air purifier include effectively filtering airborne viral particles, dust, allergens, and particulate matter. Constraints include cost, size, noise, and time. Classrooms are a unique challenge, because there are more people than in a home or a typical office, and students need to be able to hear their teacher and classmates. Schools do not have unlimited budgets, and commercial air purifiers are expensive. This makes the DIY option a more accessible option.

More information can be found at the Corsi-Rosenthal Foundation website.

Lesson Series Outline

1. Introduction to Air Quality
    a. Students will complete stations with different factors that impact air quality (temperature, particulate matter, etc.). This will help them understand the data collected by the air quality monitor.
    b. SEPs: asking questions and defining problems; analyzing and interpreting data; constructing explanations and designing solutions
2. Building the air purifier
    a. Students will build an air purifier. Students conduct a tissue test, figuring out how to increase efficiency. Students plan investigations relating to air quality or the air purifier.
    b. SEPs: asking questions; planning and conducting investigations
    c. *K-2 lesson does not include building
3. Analyzing Data
    a. Students analyze and interpret data from the air quality monitor. Students graph and interpret data from the investigation planned during lesson 2.
    b. SEPs: analyzing and interpreting data; using mathematical and computational thinking
4. Sharing the Results
    a. Students will communicate their findings to the community.
    b. SEP: constructing explanations and designing solutions; obtaining, evaluating, and communicating information

Grades K-2

Lesson 1: Air Quality

Driving Question

What is indoor air quality and why does it matter?

Student Learning Objectives

- Students will be able to ask questions, make observations, and analyze data to define a simple problem
- Students will be able to explain air quality.

NGSS Performance Expectations

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Analyzing and interpreting data

Materials

Slides, Worksheet

Lesson Sequence

1. Purpose of the lesson

a. "Today we're going to talk about air quality, and then we'll work together as scientists and engineers to solve a real problem in our classroom."

2. Introduce air quality
    a. "Do you think about the air you breathe? Have you ever?"
        i. "Have you ever seen a weather report about bad air or poor air quality? What was happening that day?"
        ii. Prompt students with images of dust, pollen, masks, smog, wildfire smoke, etc
        iii. After a short discussion, students circle things that are in the air

3. Indoor Air Quality: Show the video Clean Air for Everyone. You can play the whole thing or stop it at 1:27.
    a. Question prompts (depending on prior content)
        i. How might the air around us affect our health?
        ii. How do our bodies take in air? Where does air go when it is inside our bodies? Why does that matter?
    b. "Indoor air can have bad things floating around in it, but there are ways to capture some of the bad things."
    c. Show the gif with person and air purifier.
        i. "What do you notice? What questions do you have?"

4. Air quality monitor
    a. "Let's make predictions. What is this device? What does it tell us? Why do we have it?"
        i. The air quality monitor measures multiple factors that influence air quality. It provides some of those measures (temperature, relative humidity, etc), as well as the air quality index, a number calculated from multiple factors. The school has multiple air monitors to determine the indoor air quality.
    b. "Scientists and engineers can measure how clean the air is. They call it the air quality index. It's like a report card for the air. Let's look at this animation and think like scientists!"
    c. "Scientists and engineers use air quality monitors to measure the stuff in our air. It calculates the air quality index. We said

this was like a report card for the air. In school, the higher the number, the better the grade. In air quality, it's a little different. Let's compare the two faces on the screen. What do you notice?"

   d. Making inferences: "What do you think the colors and faces mean?"
      i. Green means good, clean air.
      ii. Yellow means dirty air.
      iii. The number is the AQI. We want it to be lower. The higher it is, the more bad stuff in the air

5. Collecting baseline data
   a. Students can collect initial data from the air quality monitor by hand or in a digital form. Younger students can draw a smiley, neutral, or sad face with the color of the air monitor.
      i. Data table in Word (best for printing and handwritten data)
      ii. Data collection form (data is compiled in spreadsheet)
   b. This step does not need to be done by the whole class. One student could travel to each air monitor, record data, and share with the class.

6. Closure: Turn and talk
   a. What was the problem we explored today?
   b. What can we do to solve the problem?

Lesson 2: Observing an Air Purifier

Driving Question

How can we improve our classroom's air quality?

Student Learning Objectives

- Students will be able to explain how the air purifier cleans air.
- Students will carry out an investigation.

NGSS Performance Expectations

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out an investigation

Materials

Slides, Tissues, DIY air purifier

Lesson Sequence

1. Purpose
    a. "What do you remember about air quality?"

2. Observing and Testing
    a. "Today we are going to investigate our very own air purifier! Let's look at the parts of it. What do you notice?"
        i. Fan pulls dirty air through the filter and pushes clean air up into the classroom. The filters "catch" the bad stuff in the air, like a net
    b. "How does it work?"
        i. Have one to four students hold a tissue about 6 inches away from the filters (one student per filter if possible). Turn the fan on. The tissue should get sucked against the filter. Students can let go of the tissue and it will stick to the filter.
    c. "How far can we hold the tissue where it will still get pulled toward the fan?"
        i. Students could work in small groups to test this.

3. Exit Ticket
    a. What is the purpose of the DIY air purifier?

        i. Cleaning the air. The fan pulls dirty air through the filters and pushes clean air out into the classroom.

4. After the lesson
    a. After the air purifier has been on for several hours, students can collect data using the air monitor or by observing the colors of the filters. It may take days or weeks for the color to change. Students should not touch the filters! They can observe at a distance and describe the changes they see.

Lesson 3: Analyzing Data

Driving Question

Is the air getting cleaner?

Student Learning Objectives

- Students will be able to analyze data to determine if a tool works.
- Students will be able to describe the trend in air quality over time.

NGSS Science and Engineering Practices

- Analyzing and interpreting data
- Constructing explanations and designing solutions

Materials

Slides, Worksheets

Lesson Sequence

1. Look at the data ahead of time and consider unexpected results (hopefully, the air quality improves over time)
    a. Air quality stayed the same: It's possible that the location of the air monitor has proper ventilation or that the school has an

efficient HVAC system. This is particularly true if the initial readings were quite low (AQI < 15) because the monitors are only sensitive down to a certain point.
    b. Air quality worsened: There could be other factors impacting levels in the classroom. The outdoor air quality might be worse, or the classroom is much more active on the day the air purifier was running.
2. Think-Pair-Share
    a. "What is the purpose of the air purifier? Can we tell if it's working?"
3. Analyzing data
    a. Students can draw a picture of the air filters or smiley/neutral faces on the air monitor or write the air quality index. They can compare this data to the baseline data they collected during lesson 1.
4. Construct an argument with evidence
    a. Students can write a sentence about their data.
5. Exit Ticket
    a. "Who would want to know about these results?"

Lesson 4: Sharing the Results

Driving Question

Who cares about the air?

Student Learning Objectives

- Students will be able to communicate scientific information.
- Students will be able to argue with evidence in writing.

NGSS Science and Engineering Practices

- Constructing explanations and designing solutions

- Obtain, evaluate, and communicate information

Materials

Slides, Worksheet

Lesson Sequence

1. What is science communication and why does it matter?
    a. "Scientists and engineers work on real-world problems and need to communicate their findings to a wide range of audiences, not just other scientists."
    b. How do scientists communicate complicated information?
2. Introduce RAFT activity. Students can choose their audience and format, but they should justify their choice.
    a. Role: student
    b. Audience
        i. Parents
        ii. Principal
        iii. Politicians
        iv. Scientists and engineers
    c. Format
        i. Letter
        ii. Presentation (slides)
        iii. Infographic
        iv. Report
    d. Topic
        i. Indoor air quality
3. Gallery Walk
    a. Have students share their RAFT products with each other!
4. Exit Ticket: How has your thinking about air quality changed?
    a. I used to think _____. Now I think _____.
5. *The final products from the RAFT should be shared with their intended audience if possible!*

Grades 3-5

Lesson 1: Air Quality

Driving Question

What is indoor air quality and why does it matter?

Student Learning Objectives

- Students will be able to define an engineering design problem, identify criteria and constraints, and analyze relevant data.
- Students will ask questions that can be investigated through experimentation.

NGSS Performance Expectations

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Analyzing and interpreting data
- Constructing explanations and designing solutions

Materials

Slides, Worksheet

Lesson Sequence

1. Engage: Think-Pair-Share

    a. "Do you think about the air you breathe? Have you ever?"
        i. Prompt students with images of dust, pollen, masks, smog, wildfire smoke, etc
    b. After a short discussion, students write 3 things in the air
2. Explore: Notice and Wonder about gif from CR foundation
    a. As the visual is displayed (play on loop), students should write what they notice and wonder.
    b. "This is a model. What do you notice? What do you wonder?"
3. Explain: Indoor Air Quality: Show the first 1:27 of the video Clean Air for Everyone.
    a. Question prompts (depending on prior content)
        i. How might the air around us affect our health?
        ii. How do our bodies take in air? Where does air go when it is inside our bodies? Why does that matter?
        iii. Is air matter? What is in the air?
    b. "Indoor air can have bad things floating around in it, but there are ways to capture some of the bad things. We want to make our air cleaner."
4. Engineering design
    a. "We are going to work together to think like engineers! Engineers define problems in order to create solutions. What is the problem we want to solve?"
        i. In small groups, students discuss and write/draw the problem
    b. "Engineers have to make sure their solutions will actually work, so they brainstorm criteria and constraints. Criteria are the things required for success. What does the solution need to do?"
        i. It needs to filter the air. More specifically, it should catch the bad stuff.
    c. "Constraints are the limitations or restrictions. Can you think of some constraints?"
        i. It can't be too big or too expensive. It shouldn't make too much noise.
5. Air quality monitor: Measuring air
    a. Make predictions. "What is this device? What does it tell us? Why do we have it?"
        i. The air quality monitor measures multiple factors that influence air quality. It provides some of those measures

(temperature, relative humidity, etc), as well as the air quality index, a number calculated from multiple factors. The school has multiple air monitors to determine the indoor air quality.

b. "What does this measure? Let's label a few important parts."
    i. Students label the parts of the air quality monitor on the worksheet: temperature, air quality index,
c. Making inferences: "What do you think the colors and faces mean?"
    i. Green means good, clean air. Yellow means dirtier air.
    ii. "Let's compare the indoor and outdoor air. Which number is bigger? Do we want AQI to be higher or lower?"
    iii. The number is the AQI. We want it to be lower. The higher it is, the more bad stuff in the air

6. Collecting baseline data
    a. Students can collect initial data from the air quality monitor by hand or in a digital form
        i. Data table in Word (best for printing and handwritten data)
        ii. Data collection form (data is compiled in spreadsheet)
    b. This step does not need to be done by the whole class. One student could travel to each air monitor, record data, and share with the class.
7. Closuring discussion
    a. "What is something we did today to be like engineers?"

Lesson 2: Building an Air Purifier

Driving Question

How can we improve our classroom's air quality?

Student Learning Objectives

- Students will be able to explain how the air purifier cleans air.
- Students will be able to ask testable questions and plan an investigation

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations

Materials

Slides, Duct Tape, 20in box fans, MERV-13 filters, Tissue/toilet paper, Scissors

Lesson Sequence

1. Engage: Show picture of DIY air purifiers
    a. What do you think this device does?
    b. What were some of the criteria and constraints that we brainstormed during the last air quality lesson?
2. Building
    a. Today we are going to build an air purifier!
    b. Assign roles to students (depending on class size and number of groups)
        i. Adhesive engineer - cuts strips of tape, helps tape edges, and cleans scissors after
        ii. Sustainability Coordinator - cuts cardboard square, ensures waste is disposed of correctly
        iii. Quality Control Engineer - checks filter direction, looks for gaps in tape
        iv. Project manager - keeps track of time and materials, can also help assemble as needed
        v. Additional roles as needed
            1. Photojournalist – take photos and write captions
            2. Art director – gathers materials for and plans decoration
    c. Play video and pause after the box fan is taped to the box, then play video from the beginning, pausing to let students follow each step

i. Gather materials. Take fan out of the box and make sure it works.
ii. Cut a 50.8 cm x 50.8 cm square from the cardboard box (approximately the large side of the box).
iii. Assemble the air filters (arrows face in, must be square). Tape edges.
iv. Tape cardboard square to top of filters. Flip it over (the cardboard is the bottom of the box)
v. Tape fan to the filters. Be sure the fan will blow air up!

3. Investigation: Is *all* the air being filtered?
    a. Conduct tissue test: *Use tissue, toilet paper, or steamers. While the fan is off, lay the tissue on the fan. The tissue will float when it is above the fan blades. At the corners, the tissue will get "pulled in," because the fan is pulling air in without the filter being in the way. The tissue will fall in the middle where the plastic is holding the fan blades, but the fan isn't "pulling" the tissue into it.*
        i. Where is the clean air leaving the fan?
        ii. Where do we want the dirty air entering the fan?
        iii. Can air sneak in without going through a filter?
    b. Use tape to close off areas where air can sneak in
4. Planning an investigation
    a. Students can plan an investigation using the air monitors or observing the filters. They can choose variables, outline a procedure, and determine what data to collect.
    b. Possible variables include location in classroom, fan speed, number of students in the classroom, etc.
5. Closing discussion
    a. What is the purpose of the DIY air purifier?
        i. Cleaning the air. The fan pulls dirty air through the filters and pushes clean air out into the classroom.
    b. What is the purpose of the shroud?
        i. Shroud blocks dirty air from getting into the fan without going through the filters.

Lesson 3: Analyzing Data

Driving Question

Is the air getting cleaner?

Student Learning Objectives

- Students will be able to transform raw data into a visual representation.
- Students will be able to explain the trend in air quality over time.

NGSS Science and Engineering Practices

- Analyzing and interpreting data
- Using mathematical and computational thinking
- Constructing explanations and designing solutions

Materials

Slides, Worksheets

Lesson Sequence

1. Look at the data ahead of time and consider unexpected results (hopefully, the air quality improves over time)
    a. Air quality stayed the same: It's possible that the location of the air monitor has proper ventilation or that the school has an efficient HVAC system. This is particularly true if the initial readings were quite low (AQI < 15) because the monitors are only sensitive down to a certain point.
    b. Air quality worsened: There could be other factors impacting levels in the classroom. The outdoor air quality might be worse, or the classroom is much more active on the day the air purifier was running.
2. Think-Pair-Share

    a. What is the purpose of the air purifier?
    b. What data can we collect to determine if the air purifier is working?
3. Collect and transform raw data
    a. Observe the color of the filters on the air purifier.
    b. Raw data from one or more air monitors.
    c. Graph by hand or spreadsheet
4. Claim, evidence, reasoning
    a. What does the data tell us? Write a claim.
    b. What evidence do we have to support the claim?
    c. What is the reason behind the claim? *Why* are the data like this?
5. Closing discussion
    a. Who would want to know about these results?
    b. How might we present the results to that audience?

Lesson 4: Sharing the Results

Driving Question

Who cares about the air?

Student Learning Objectives

- Students will be able to communicate scientific information to a specific audience.
- Students will be able to argue with evidence in writing.

NGSS Science and Engineering Practices

- Constructing explanations and designing solutions
- Obtain, evaluate, and communicate information

Materials

Slides, Worksheet

Lesson Sequence

1. What is science communication and why does it matter?
    a. Scientists and engineers work on real-world problems and need to communicate their findings to a wide range of audiences, not just other scientists.
    b. How do scientists communicate complicated information?
2. Introduce RAFT activity. Students can choose their audience and format, but they should justify their choice.
    a. Role: student
    b. Audience
        i. Parents
        ii. Principal
        iii. Politicians
        iv. UConn researchers
    c. Format
        i. Social media post(s) or campaign
        ii. Letter
        iii. Presentation (slides)
        iv. Infographic
        v. Report
    d. Topic
        i. Indoor air quality
3. Gallery Walk
    a. Have students share their RAFT products with each other!
4. Exit Ticket: How has your thinking about air quality changed?
    a. I used to think _____. Now I think _____.
5. *The final products from the RAFT should be shared with their intended audience if possible!*

Grades 6-8

Lesson 1: Air Quality

Driving Question

What is indoor air quality and why does it matter?

Student Learning Objectives

- Students will be able to define an engineering design problem, identify criteria and constraints, and analyze relevant data.
- Students will ask questions that can be investigated through experimentation.

NGSS Performance Expectations

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations and designing solutions

Materials

Slides, Stations, Worksheet

Lesson Sequence

1. Think-Pair-Share
    a. Do you think about the air you breathe? Have you ever?
    b. Consider dust, pollen, viruses, smog, etc
2. Display the air quality monitor
    a. Either generic photo that is in the slides OR add a photo from one of the school monitors, so students can see real data
    b. What is this device? What does it tell us? Why do we have it?
        i. The air quality monitor measures multiple factors that influence air quality. It provides some of those measures (temperature, relative humidity, etc), as well as the air quality index, a number calculated from multiple factors. The school has multiple air monitors to determine the indoor air quality.
3. Exploration: Stations or Jigsaw This can be set up as stations so that all students practice all skills, or it can be a jigsaw where students focus on one "station" and share out what they learned with others.
    a. Analyzing and interpreting data: Temperature
        i. Students will interpret a graph about the effect of temperature on student learning
    b. Defining problems (engineering)
        i. Infographic about indoor air quality in schools
        ii. Students will define the problem, brainstorm criteria and constraints of a solution
    c. Air Quality and Human Health
        i. Watch American Lung Association video.
        ii. 3-2-1
            1. 3 things you learned
            2. 2 questions you have
            3. 1 emotion or reaction to this video
    d. Asking questions (science)
        i. Read about AQI and PM
        ii. Write testable questions and hypotheses relating to AQI and/or PM
    e. Analyzing and interpreting data: PM
        i. Students will interpret a graph about the effect of particulate matter on math test scores

4. Collecting baseline data
    a. Students can collect initial data from the air quality monitor by hand or in a digital form
        i. Data table in Word (best for printing and handwritten data)
        ii. Data collection form (data is compiled in spreadsheet)
    b. This step does not need to be done by the whole class. One student could travel to each air monitor, record data, and share with the class.
5. Closure (discuss or have students write as exit ticket)
    a. Show the air quality monitor from the beginning class. Has the air quality changed during class?
    b. What does the air monitor tell us? What can we learn from it over time?

Lesson 2: Building an Air Purifier

Driving Question

How can we improve our classroom's air quality?

Student Learning Objectives

- Students will be able to explain how the air purifier cleans air.
- Students will be able to ask testable questions and plan an investigation

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations

Materials

Slides, Duct tape, 20in box fans, MERV-13 filters, Tissue/toilet paper, Scissors

Lesson Sequence

1. Engage: Show picture of DIY air purifiers
    a. What do you think this device does?
    b. What were some of the criteria and constraints that we brainstormed during the last air quality lesson?
2. Building
    a. Today we are going to build an air purifier!
    b. Assign roles to students (depending on class size and number of groups)
        i. Adhesive engineer - cuts strips of tape, helps tape edges, and cleans scissors after
        ii. Sustainability Coordinator - cuts cardboard square, ensures waste is disposed of correctly
        iii. Quality Control Engineer - checks filter direction, looks for gaps in tape
        iv. Project manager - keeps track of time and materials, can also help assemble as needed
        v. Additional roles as needed
            1. Photojournalist – take photos and write captions
            2. Art director – gathers materials for and plans decoration
    c. Play video and pause after the box fan is taped to the box, then play video from the beginning, pausing to let students follow each step
        i. Gather materials. Take fan out of the box and make sure it works.
        ii. Cut a 50.8 cm x 50.8 cm square from the cardboard box (approximately the large side of the box).
        iii. Assemble the air filters (arrows face in, must be square). Tape edges.
        iv. Tape cardboard square to top of filters. Flip it over (the cardboard is the bottom of the box)

        v. Tape fan to the filters. Be sure the fan will blow air up!
3. Investigation: Is *all* the air being filtered?
    a. Conduct tissue test: *Use tissue, toilet paper, or steamers. While the fan is off, lay the tissue on the fan. The tissue will float when it is above the fan blades. At the corners, the tissue will get "pulled in," because the fan is pulling air in without the filter being in the way. The tissue will fall in the middle where the plastic is holding the fan blades, but the fan isn't "pulling" the tissue into it.*
        i. Where is the clean air leaving the fan?
        ii. Where do we want the dirty air entering the fan?
        iii. Can air sneak in without going through a filter?
    b. Use tape to close off areas where air can sneak in
4. Planning an investigation
    a. Students can plan an investigation using the air monitors or observing the filters. They can choose variables, outline a procedure, and determine what data to collect.
    b. Possible variables include location in classroom, fan speed, number of students in the classroom, etc.
5. Exit Ticket
    a. What is the purpose of the DIY air purifier?
        i. Cleaning the air. The fan pulls dirty air through the filters and pushes clean air out into the classroom.
    b. What is the purpose of the shroud?
        i. Shroud blocks dirty air from getting into the fan without going through the filters.

Lesson 3: Analyzing Data

Driving Question

Is the air getting cleaner?

Student Learning Objectives

- Students will be able to transform raw data into a visual representation.
- Students will be able to explain the trend in air quality over time.

NGSS Science and Engineering Practices

- Analyzing and interpreting data
- Using mathematical and computational thinking
- Constructing explanations and designing solutions

Materials

Slides, Worksheets

Lesson Sequence

1. Look at the data ahead of time and consider unexpected results (hopefully, the air quality improves over time)
    a. Air quality stayed the same: It's possible that the location of the air monitor has proper ventilation or that the school has an efficient HVAC system. This is particularly true if the initial readings were quite low (AQI < 15) because the monitors are only sensitive down to a certain point.
    b. Air quality worsened: There could be other factors impacting levels in the classroom. The outdoor air quality might be worse, or the classroom is much more active on the day the air purifier was running.
2. Think-Pair-Share
    a. What is the purpose of the air purifier?
    b. What data can we collect to determine if the air purifier is working?
3. Collect and transform raw data
    a. Raw data from one or more air monitors
    b. Graph by hand or spreadsheet
4. Claim, evidence, reasoning

    a. What does the data tell us? Write a claim.
    b. What evidence do we have to support the claim?
    c. What is the reason behind the claim? *Why* are the data like this?
5. Exit Ticket
    a. Who would want to know about these results?
    b. How might we present the results to that audience?

Lesson 4: Sharing the Results

Driving Question

Who cares about the air?

Student Learning Objectives

- Students will be able to communicate scientific information to a specific audience.
- Students will be able to argue with evidence in writing.

NGSS Science and Engineering Practices

- Constructing explanations and designing solutions
- Obtain, evaluate, and communicate information

Materials

Slides, Worksheet

Lesson Sequence

1. What is science communication and why does it matter?

    a. Scientists and engineers work on real-world problems and need to communicate their findings to a wide range of audiences, not just other scientists.
    b. How do scientists communicate complicated information?
2. Introduce RAFT activity. Students can choose their audience and format, but they should justify their choice.
    a. Role: student
    b. Audience
        i. PTO
        ii. School Board
        iii. Politicians?
    c. Format
        i. Social media post(s) or campaign
        ii. Letter
        iii. Presentation (slides)
        iv. Infographic
        v. Report
    d. Topic
        i. Indoor air quality
3. Gallery Walk
    a. Have students share their RAFT products with each other!
4. Exit Ticket: How has your thinking about air quality changed?
    a. I used to think _____. Now I think _____.
5. *The final products from the RAFT should be shared with their intended audience if possible!*

Grades 9-12

Lesson 1: Air Quality

Driving Question

What is indoor air quality and why does it matter?

Student Learning Objectives

- Students will be able to define an engineering design problem, identify criteria and constraints, and analyze relevant data.
- Students will ask questions that can be investigated through experimentation.

NGSS Performance Expectations

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations and designing solutions

Materials

Slides, Stations, Worksheet

Lesson Sequence

1. Think-Pair-Share
    a. Do you think about the air you breathe? Have you ever?
    b. Consider dust, pollen, viruses, smog, asthma, etc
2. Display the air quality monitor
    a. Either generic photo that is in the slides OR add a photo from one of the school monitors, so students can see real data
    b. What is this device? What does it tell us? Why do we have it?
        i. The air quality monitor measures multiple factors that influence air quality. It provides some of those measures (temperature, relative humidity, etc), as well as the air quality index, a number calculated from multiple factors. The school has multiple air monitors to determine the indoor air quality.
3. Exploration: Stations or Jigsaw This can be set up as stations so that all students practice all skills, or it can be a jigsaw where students focus on one "station" and share out what they learned with others. (Link to Worksheet)
    a. Analyzing and interpreting data: Temperature
        i. Students will interpret graphs about the effect of temperature on student learning.
    b. Defining problems (engineering)
        i. Infographic about indoor air quality in schools
        ii. Students will define the problem, brainstorm criteria and constraints of a solution
    c. Air Quality and Human Health
        i. Watch American Lung Association video.
        ii. Write three sentences how air quality can affect health
    d. Asking questions (science)
        i. Read about AQI and PM
        ii. Write testable questions and hypotheses relating to AQI and/or PM
    e. Analyzing and interpreting data: PM
        i. Students will interpret graphs about the effect of particulate matter on student learning.
4. Collecting baseline data

    a. Students can collect initial data from the air quality monitor by hand or in a digital form
        i. Data table in Word (best for printing and handwritten data)
        ii. Data collection form (data is compiled in spreadsheet)
    b. This step does not need to be done by the whole class. One student could travel to each air monitor, record data, and share with the class.
5. Closure (discuss or have students write as exit ticket)
    a. Show the air quality monitor from the beginning class. Has the air quality changed during class?
    b. What does the air monitor tell us? What can we learn from it over time?

Lesson 2: Building an Air Purifier

Driving Question

How can we improve our classroom's air quality?

Student Learning Objectives

- Students will be able to explain how the air purifier cleans air.
- Students will be able to ask testable questions and plan an investigation

NGSS Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations

Materials

Slides, Duct tape, MERV-13 filters, 20in box fans, Tissue/toilet paper, Scissors

Lesson Sequence

1. Engage: Show pictures of DIY air purifiers
    a. What do you think these devices do?
    b. What were some of the criteria and constraints that we brainstormed during the last air quality lesson?
2. Building
    a. Today we are going to build an air purifier!
    b. Assign roles to students (depending on class size and number of groups)
        i. Adhesive engineer - cuts strips of tape, helps tape edges, and cleans scissors after
        ii. Sustainability Coordinator - cuts cardboard square, ensures waste is disposed of correctly
        iii. Quality Control Engineer - checks filter direction, looks for gaps in tape
        iv. Project manager - keeps track of time and materials, can also help assemble as needed
        v. Additional roles as needed
            1. Photojournalist – take photos and write captions
            2. Art director – gathers materials for and plans decoration
    c. Play video and pause after the box fan is taped to the box, then play video from the beginning, pausing to let students follow each step
        i. Gather materials. Take fan out of the box and make sure it works.
        ii. Cut a 50.8 cm x 50.8 cm square from the cardboard box (approximately the large side of the box).
        iii. Assemble the air filters (arrows face in, must be square). Tape edges.
        iv. Tape cardboard square to top of filters. Flip it over (the cardboard is the bottom of the box)

v. Tape fan to the filters. Be sure the fan will blow air up!

3. Investigation: Is *all* the air being filtered?
    a. Conduct tissue test: *Use tissue, toilet paper, or steamers. While the fan is off, lay the tissue on the fan. The tissue will float when it is above the fan blades. At the corners, the tissue will get "pulled in," because the fan is pulling air in without the filter being in the way. The tissue will fall in the middle where the plastic is holding the fan blades, but the fan isn't "pulling" the tissue into it.*
        i. Where is the clean air leaving the fan?
        ii. Where do we want the dirty air entering the fan?
        iii. Can air sneak in without going through a filter?
    b. Use tape to close off areas where air can sneak in
4. Planning investigations Link to Worksheet
    a. Students can plan an investigation using the air monitors or observing the filters. They can choose variables, outline a procedure, and determine what data to collect.
    b. Possible variables include location in classroom, fan speed, number of students in the classroom, etc.
5. Exit Ticket
    a. What is the purpose of the DIY air purifier?
        i. Cleaning the air. The fan pulls dirty air through the filters and pushes clean air out into the classroom.
    b. What is the purpose of the shroud?
        i. Shroud blocks dirty air from getting into the fan without going through the filters.

Lesson 3: Analyzing Data

Driving Question

Is the air getting cleaner?

Student Learning Objectives

- Students will be able to transform raw data into a visual representation.
- Students will be able to explain the trend in air quality over time.

NGSS Science and Engineering Practices

- Analyzing and interpreting data
- Using mathematical and computational thinking
- Constructing explanations and designing solutions

Lesson Sequence

1. Look at the data ahead of time and consider unexpected results (hopefully, the air quality improves over time)
    a. Air quality stayed the same: It's possible that the location of the air monitor has proper ventilation or that the school has an efficient HVAC system. This is particularly true if the initial readings were quite low (AQI < 15) because the monitors are only sensitive down to a certain point.
    b. Air quality worsened: There could be other factors impacting levels in the classroom. The outdoor air quality might be worse, or the classroom is much more active on the day the air purifier was running.
2. Think-Pair-Share
    a. What is the purpose of the DIY air purifier?
    b. What data can we collect to determine if the DIY air purifier is working?
3. Collect and transform raw data
    a. Raw data from one or more air monitors
    b. Graph by hand or spreadsheet
4. Claim, evidence, reasoning (Worksheet)
    a. What does the data tell us? Write a claim.
    b. What evidence do we have to support the claim?
    c. What is the reason behind the claim? *Why* are the data like this?
5. Exit Ticket

a. Who would want to know about these results?
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    b. Audience
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    c. Format

        i. Social media post(s) or campaign
        ii. Letter
        iii. Presentation (slides)
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3. Gallery Walk
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4. Exit Ticket: How has your thinking about air quality changed?
    a. I used to think _____. Now I think _____.
5. *The final products from the RAFT should be shared with their intended audience if possible!*