How Can Technology Help Reduce Our Waste?

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Phenomenon/Problem

Students are tasked with shipping school supplies using the least amount of shipping materials possible.

Materials

- Amazon PACK Clip of FC Tour
  www.youtube.com/watch?v=egf6ibRePAk&t=40s
- “What Happens Inside a Landfill,” article from Live Science.
- highlighters (enough for each student to have 2 different colors)

For Task

- Variety of different school supplies
- Variety of shipping boxes and packing materials
- Rulers
- Scale
- Whiteboards or chart paper
- Dry erase markers

Material Management Tips

- Have video queued and ready to play.
- Print article and have highlighters ready or have article ready to share using a digital format/tool.
- Prepare a materials table to give students easy access to the materials available.
### Science and Engineering Practice(s)

**Planning and Carrying Out Investigations**
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomena or test a design solution.
- Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.

### Disciplinary Core Ideas

**ESS3.C: Human Impacts on Earth Systems**

Human activities in industry and everyday life have had major effects on the land. But individuals and communities are doing things to help protect Earth’s resources and environment.

**ETS1.B: Developing Possible Solutions**

At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

### Crosscutting Concepts

**Patterns**

Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products.

**Cause and Effect**

Cause-and-effect relationships are routinely identified, tested, and used to explain change.

### Supporting Equitable Participation

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### Modalities

**How students communicate their ideas**

- **Talk** • **Text** • **Visual**: Drawing, Symbols, Table, Graph, Chart, and Gesture

### Safety

NSTA encourages K–12 teachers and school leaders to promote and support the use of science activities in science instruction and work to avoid and reduce injury. Additionally, NSTA recommends teachers and school leaders visit the NSTA Safety Resource page for up-to-date information on safety issues and guidelines.
EXPERIENCE PHENOMENON

Students experience the phenomenon or problem. The teacher creates an opportunity for students to connect with this specific event or problem (through prior experience, interests, and curiosities) and raise or identify a student question to investigate.

1. Introduce the Phenomenon

Tell students that you have been working on a school supply distribution project and have a lot of different items to ship to different places. Consider using a current event to provide a real-life context for students. (For example, you might send school supplies to schools affected by a natural disaster.) Break students into groups and provide each group with a set of different items, a box (make sure all of the groups receive boxes that are the same size), and other packing materials. Before students begin packing school supplies, note the time and write it on the board. Instruct students to pack the school supplies in the provided box and make sure the packed items don’t move around inside the box when the box is tilted or turned upside down. Because students need to reuse the box, tell them not to tape it closed. Tell each group to let you know when they have finished packing, and record the end time for each group.

Record and label the average time it took the class to pack school supplies into boxes.

After completing the task, ask students if they think they could have packed the items into the box differently. What might they do differently the next time? Why?

Give groups time to think about the question and generate a few ideas. Have groups share their ideas with the whole class. Many students will say that they could have used a box of a different size or different packing materials. For example, they might use bubble wrap or air “pouches” instead of packing peanuts. They might choose a smaller (or larger) box. Make sure to ask students to share why they would make these changes.
2. Designing a Solution

Use student ideas about choosing boxes of a more appropriate size to ship the school supplies to prompt them to think about designing solutions to a problem. Ask students to brainstorm with their group members all of the ways that using boxes of a more appropriate size could help reduce waste. Have each group share at least one idea with the whole class. Student ideas will vary, but could include these:

- Smaller boxes are made from less cardboard than larger boxes.
- Less unused space in the box means you don’t need a lot of packing materials to keep the items in place.
- A smaller box would probably weigh less, helping you save money when shipping boxes to different places.
- Smaller boxes containing less packing materials means you’ll have less materials to throw away or recycle.

Acknowledge all student ideas; summarize students’ ideas about how using smaller (more appropriately sized) boxes requires a smaller amount of resources and produces less waste.

Inform students that each request for school supplies needed to be packed and shipped contains different items and different amounts of each item. For example, one request might call for 6 boxes of pencils and 10 notebooks, while another order must have 10 sets of colored markers and 3 bundles of construction paper. Show students that you have gathered boxes of many different sizes to accommodate the various school supply requests. Allow students to see the boxes that are available for them to use. You may also obtain samples of these boxes (or similar ones) from your local post office. Ask students, “Which box might you use to ship the school supplies assigned to you in the first task? Why do you say so?”

Student groups brainstorm ideas about how using a box of a different size could help reduce waste. Groups share one idea with the whole group.

Students observe the various sizes of boxes available to pack and ship school supplies.

Students share their thinking about which size box they would use to ship the school supplies assigned to their group and what they considered before making a decision.

If only a few students volunteer, ask them to turn and share their ideas with a partner, then pose the question to the class again.
INVESTIGATE

Students engage in the practices of scientists and engineers to build understanding of targeted science ideas (and engineering ideas) needed to explain the phenomenon or solve the problem.

3. Developing Criteria and Defining Constraints

Remind students of the problem they are trying to solve by writing it in a common area or displaying it in a shared digital space: **Can we design a packing process that helps us ship school supplies using the least amount of packing materials?** Clarify for students that the goal is to create a process that when followed, always results in using the least amount of packing materials possible, and that packing materials include the box and the materials placed on and around the school supplies in the box.

Tell students, “We need to consider how we would know/be able to tell if we were using the least amount of packing materials possible.” Ask students to discuss their ideas with a partner.

Create a t-chart in the common space and write the heading Criteria for Success on the left side. Invite students to share their ideas about how to determine if a packed box of school supplies contains the least amount of packing possible, and list these ideas in the left column. Students will likely contribute some or all of the following ideas:

- The school supplies don’t fit together inside the next-smallest-size box.
- No additional school supplies fit inside the box.
- The school supplies don’t move when the box is tilted or turned upside down.
- When you remove one piece/sheet of packing, the school supplies move when the box is tilted or turned upside down.
- The box lid closes flat (and/or the box doesn’t “bulge” when closed).
For each shared idea, ask students to show agreement (thumbs up) or disagreement (thumbs down) with including it on the list of criteria. Encourage students to ask one another clarifying questions and to add to/build on one another’s ideas.

Students use their thumbs to indicate agreement (thumbs up) or disagreement (thumbs down) with including each idea on the list of criteria.

Students ask one another clarifying questions to help determine if an idea should be included on the list of criteria. They could use teacher-provided sentence stems such as these:

- How is … different from ….?
- What’s another way you might say/describe…?

If students do not mention the amount of time it takes to select packing materials and pack the school supplies in the box, tell them the average time the class took to pack the school supplies in the previous task. Then ask students, “Do you think we should consider how long it takes to select materials and pack the school supplies in the box as a criterion for success? We each only packed one box today. What if we needed to pack 100 boxes today? Or 100 boxes every day for one week?”

Ask students to hold their thumbs up if they think time should be added to the list of criteria and thumbs down if they think time should not be included. If the class is nearly evenly divided, ask two students with thumbs up to share their thinking with the class, then invite two students with their thumbs down to share their ideas. Re-poll the class to see if consensus has been reached (most students agree that time should be a criterion, and the rest of the students accept the idea even if they don’t completely agree).

Ask students how they could measure (quantify) time. Students might say the process should take less than the average class time to pack the box in the first task. Ask students to define when the packing process begins and ends.

Other students may suggest counting the number of “tries” it takes to use the least possible amount of packing materials. For example, students might suggest the criterion is “must package the school supplies in one try.”

Add time to the list of criteria for success.
Tell students that engineers must also consider constraints, which place limits on the design of the solution. Label the right side of the t-chart Constraints and add these constraints to the right column:

- Standard size boxes only;
- May only use the packing materials provided;
- May not use tape to hold the school supplies in place;
- May not remove school supplies from their original packaging or change the shape of the original packaging;
- Running to pick up packing materials and throwing materials to team members is not allowed; and
- Time to design the packing process is ____ minutes. (This depends on amount of time allotted for the lesson; 10–20 minutes should be sufficient.)

4. Collecting Data to Guide Decision Making

Ask students what they think they need to know to be able to design a packing process that meets the criteria for success. Many students will reply that they need to know exactly what will go into each school supply package. Ask students how they would use that information to decide which size box to use. Give students one to two minutes to think about the question independently, then two minutes to discuss with a partner. Students jot their ideas (words, pictures, symbols, etc.) in an appropriate space, then share these ideas with a partner.

Bring students back together and ask them to share their ideas. Summarize the class’s thinking by saying, “Let me see if I’ve understood you correctly. Are you saying we can use the school supplies on our packing list to decide immediately which box sizes we can’t use?” (Leave space for students to respond.) “How would we do that?” Students review the ideas they recorded and share their thoughts about how they would decide if a box was too small to use (or otherwise not suitable) for the job.

Students will likely share that they would look at the school supplies, then examine the boxes and compare their sizes. Other students might further suggest placing the items on their packing list in a box and choosing the next largest or next smallest box if the items did not fit correctly.
Ask students, “What data could we collect and how would we use that data to be sure (confident) the school supplies would fit into the box we chose before we placed the items in the box?” Again, give students one to two minutes of independent thinking time before asking them to share ideas with a partner or small group.”

As you move around the room, listen for students to share ideas about needing to know how big the school supplies are and how big the boxes are. Follow up with questions such as, “How would you measure how big the school supplies are?” “What would you measure?” (You might show students a package of pencils and ask them to tell or show what they would measure.) “Do you think we need to measure all of the school supplies?” “Do you think we need to measure the boxes? What would you measure on the boxes?” (Again, you might show students a box and ask them to tell or show what they would measure.)

Bring the class back together. Ask for volunteers to share the types of data the class needs to collect, but be sure to call on those students who shared with partners (or small groups) ideas about measuring the school supplies and boxes. The class will likely generate the following list:

- **School supplies**: height, width, and length; and
- **Boxes**: height, width, and length. (Students may also suggest measuring length on the diagonal: corner to opposite corner [two-dimensional] and/or bottom corner to opposite top corner [three-dimensional].)

If students do not identify the information (data) listed above, use probing questions to move their thinking toward quantifying information about the school supplies and boxes. Suggested prompts include these:

- Is there anything else we might need to know?
- Are we missing any information about the school supplies or boxes and other packing materials?
- Does the information we need for the school supplies match the information we identified for the boxes and other packing materials?

Students again review the ideas they recorded and add to them using words, pictures, symbols, etc.
Students may include weight of school supplies; this can be added to the list later if the need to measure the weight arises.

Next, remind students of the problem: Design a packing process that uses the least amount of packing materials.

Ask students, “Now that we’ve identified the information we need, how can we collect and organize the data?” Students should reply that they need to measure all the different types of school supplies and all the boxes.

Agree with students. Inform them that you obtained measurements for the boxes from the post office or other source of boxes (see example below), and they only need to measure the types of school supplies.

Ask students to return to their original packing group and assign each group different types of school supplies to measure. Remind them that they will need to collect several measurements: height, width, and length. (Note: Students may now wish to also measure weight because the data provided for the boxes includes the maximum weight each box can hold.)

Tell students that they should agree on a way to organize the data they are collecting so they can easily share it with the class.

**Additional Guidance**

If you have limited time, you may choose to provide students with blank data tables instead of asking them to create their own. You could also choose to collaboratively develop a class data table (on a whiteboard or poster paper, or in a shared digital space,) then ask students to record their measurements in that data table.

**Differentiation**

Depending on the grade you are working with and/or the available time, you could record all the measurements in advance so students would not have to measure anything. You could also differentiate the kinds of items students would need to measure. Other ways to differentiate could include giving students only one type of item to ship or only those of a certain shape.
Designing a Packing Process

Bring the class back together. Tell students, “We now have data for all of the boxes and school supplies we need to ship to other schools. Your task now is to use our experience with packing boxes (at the beginning of the lesson) and the data we collected to design a packing process to help us use the least amount of packing material. We can use our criteria and constraints to determine if the processes we design are successful.

Make sure students understand that by process, you mean an ordered series of steps that when followed, achieves the desired goal. You might also tell students that the process needs to be communicated clearly so others can follow the steps to achieve the same goal.

Remind students that they have already identified one step in the process: Compare the size of a school supply item with the sizes of the boxes. In addition, tell them that they identified the need to use data to make the comparison and feel confident that the school supply item would fit.

Distribute a list of school supplies that is identical to the types and numbers of each type of school supplies that students packed in their box in the first task. Ask students what steps they would follow to pack these school supplies using the least amount of packing materials. These steps make up their packing process.

Give students time to work independently to develop a series of steps they could follow to choose the box in which to pack the school supplies that would require the least amount of packing materials. Then assign students to small groups to develop a group consensus packing process.

As students work, walk around and encourage them to use words, pictures, symbols, tables, etc., when recording their process to communicate the steps as clearly as possible. When student groups complete their process, ask them to test it using the school supplies on the list. You might ask student groups some or all of the following questions:

- Did your packing process meet the criteria for success?
- What is your favorite part of your packing process? Why do you say so?

Students work independently to develop an ordered series of steps to determine which size of box will accommodate all of the school supplies while requiring the least amount of packing material. Students use words, pictures, symbols, tables, etc., to communicate their ideas.

Students work with their group members to reach consensus on an ordered series of steps that allows the person using the packing process to achieve the goal of packing school supplies using the least amount of packing materials.

Student groups test and improve their packing process as time allows.
• Engineers are always seeking ways to improve their processes (technologies). What might you change about or add to your packing process? How would this change/addition improve the packing process?
• Could you use this packing process with any list of school supplies? Why do you say so?

Bring students back together. Ask them to retrieve the boxes they packed in the first task and compare the amount of packing materials they used when they first packed the school supplies to the amount of packing materials they used when following their packing process. Did they use less packing materials when following the packing process? How much less? (This comparison can be made using qualitative—same, less, much less—and/or quantitative data depending on the available time and student experience.

The class will likely recognize that employing a packing process reduced the amount of packing materials used to pack the school supplies.

Ask each student group to present their packing process to the class. Consider asking the groups to share the answers to some or all of the following questions in their (informal) presentation of their packing process to the class:
• Did your packing process meet the criteria for success?
• What is your favorite part of your packing process? Why do you say so?
• What might you change about or add to your packing process? How would this change/addition improve the packing process?

Make sure to point out that while many of the groups’ packing process met the criteria for success, not all packing processes were alike. More than one solution exists for every problem.
If time allows, you might try one or both of the following methods for further testing each group’s packing process.

- Ask groups to exchange packing processes and follow the other group’s packing process to pack the school supplies. Ask, “Did you get the same results as the group who designed the packing process?”
- Present each group with a new list of school supplies and ask them to use their packing process to pack them. Did the packing process meet the criteria for success when packing a different set of school supplies?

Again, if time permits, allow students to revise their packing process based on feedback from the other group or their experience packing a new set of school supplies.

**Comparing Packing Processes to Packing Processes Designed by Amazon Engineers**

Tell students that engineers often research other solutions to design or improve their own solutions. Share that you recently participated in a virtual tour of Amazon fulfillment centers and would like them to watch a video clip from that tour.

Ask students to compare their own packing process to the one designed by Amazon engineers. Encourage students to record ideas they could use to improve their own packing process designs. Also encourage students to record questions they have about other information presented in the clip. Play the Amazon PACK Clip of FC Tour.

Give students three to five minutes to discuss their observations of Amazon’s packing process and any questions they have about the Amazon fulfillment center with their group members. Tell students you will ask each group to share one similarity or difference between Amazon’s packing process and their group’s packing process and something shared in the video that they thought was interesting.

Students record ideas to improve their packing process while watching the video clip from the Amazon fulfillment center tour.

Students talk with their group members to identify at least one similarity or difference between Amazon’s packing process and their own packing process.
Bring the students back together and invite each group to share. Ask the class one or more of the following questions to help build understanding about designing solutions to problems.

- Do you think Amazon’s criteria and constraints are similar to our criteria and constraints? Why do you say so?
- What are common similarities between our packing processes and Amazon’s packing process?
- How are our packing processes most different from Amazon’s packing process? What might be the cause for these big differences?
- Do you think other companies use packing processes? What are some examples?
- How does using a packing process help a company reduce waste? A school? A community?

Extension Opportunity

Consider having students develop their own algorithm that could be used to choose the proper box to ship a bundle of items. Depending on the technology available, students could develop this using paper and pencil or digital tools.

Connecting Technology to Community

Now that students have figured out there’s a best way to determine what packing materials should be used, remind them of the criteria for success, which include using the least amount of packing materials.

Now that students are thinking about reducing waste, ask them to share any questions they have about waste (garbage) and/or recycling. Student questions may include these:

- Why is it important to reduce waste?
- Is Amazon really saving two billion boxes?
- What do we do with the boxes and other packing material after the packages are delivered?
- Can all of the packing materials be recycled?
- Why would Amazon recycle boxes if they always need boxes? Couldn’t they just reuse them?
Ask students, “What do we think counts as waste?” (What do we mean when we use the word waste?) Have students turn to a partner and share their ideas before asking them to share ideas with the class. Students will likely agree that waste is anything that can’t be used or isn’t needed anymore. If you have both garbage cans and recycling bins in your classroom, point out that some waste goes in the garbage can and some waste goes in the recycle bin.

Next, ask students to think about where waste goes when it leaves the school or their home. Allow students time to share ideas with a partner or small group, then invite students to share ideas with the class. Many students will say that waste is taken to a landfill (sometimes referred to as a “dump”) or recycling center; some students may share experience with composting waste.

Focus students’ attention on waste that is sent to landfills. Ask them, “What happens to waste after it arrives at the landfill?” Instruct students to independently record their ideas.

Share with students “What Happens Inside a Landfill,” a short article from Live Science. As students read the article, you might choose to encourage them to highlight ideas they think are important in one color and designate a second color for highlighting things they have questions about.

When the class is ready to discuss the article, say, “Now that we have some information about landfills, let’s see if we can figure out why it might be important to reduce the amount of waste we send there.” Ask students to return to their small groups to share ideas about why it would be important to keep waste out of the landfill.

Bring the groups back together and ask each group to share an idea about why it might be important to reduce the amount of waste we send to landfills. Student ideas could include all or some of the following ideas:

- We could run out of space.
- Garbage makes methane gas.
- Methane gas is bad for the environment/is flammable/is a greenhouse gas.
- Just covering up garbage doesn’t get rid of it.
Now that students are thinking about important reasons to keep waste out of landfills, ask them, “Why would it be important for Amazon to use the smallest amount of packing material when packing and shipping products to our homes/schools?” Have students discuss this question in small groups.

Bring the class back together and ask the students to share their group’s thinking. Student ideas will vary, but most students will likely conclude that Amazon wants to reduce the amount of packing materials they use to help keep waste out of landfills. Next, ask students about the two billion boxes Amazon saved (by not using them) over the past five years. Ask, “How do you think Amazon saved so many boxes? Do you think they started reducing the number of boxes they used all at once or a little at a time?” Facilitate a whole-group discussion that leads students to figuring out that small changes, like using a smallest box appropriate for the job, can lead to big savings over time.

Remind students that everyday human activities have an effect on the Earth. Have students think about something they can do individually or as a class that would help reduce waste.

**REFLECT**

Students use the new or revised science ideas they developed to help explain how or why the phenomenon occurs and/or to identify solutions to the problem.

**5. What did we figure out? [Making Sense]**

To ensure students have made the important connections to the learning, have students work in groups to develop an explanation about why something like the size of a shipping box matters and how that simple choice can make a difference. Students will develop different explanations, but look for key connections such as these:

- Choosing a smaller box ensures less waste.
- Having less waste is better because we don’t know if the box will be thrown away or recycled.
- Choosing the right size of box every time helps save a lot of boxes.
- Every time we can keep something out of the trash, it is good—even if it is just a small amount of stuff.

Students make connections to the learning by developing an explanation about why something as simple as the choice of the shipping box would matter. Students figure out that small changes can make big differences over time and that their choices can help make a difference.
Empower students by emphasizing they can help reduce waste in other daily choices they make. Have students brainstorm ideas about something they could do at home or school to help reduce waste. Ask, “Is there a system you could develop that you could use at home?” Allow students time to formulate their ideas before asking them to share with the class. After students share their ideas, encourage them to also tell their families about their ideas.

Students individually brainstorm ideas about things they could do at home or at school to help reduce waste. Students share their ideas with the class.

Last, revisit the lesson question: How can technology help reduce our waste? Ask students to think about Emily from the video and how she knew what box to use. Students may answer that the computer told her what box to use. Ask students what information the computer used to choose the box. Give students a few minutes to discuss their ideas with a partner or small group. If you notice students are struggling, remind them of the data they collected and used to figure out which box to choose to ship their assigned school supplies. Consider using the following prompts:

- To choose the best box, what data did we need? How did we use that data?
- Do you think Amazon needs the same data or different data? Why do you say so?

Students revisit the lesson question: How can technology help reduce our waste? Together they will also think about ways technology is making it easier for Amazon to reduce its waste. Students work together to revise their explanations or develop new ones to answer this question.

Students should reach the conclusion that the computer knows what box to tell the packer to use based on all the same information they used in class. Play the video Amazon PACK Clip of FC Tour (https://www.youtube.com/watch?v=egf6ibReP&k&t=40s) from 0:50 to 3:47.

Individually or in small groups, have students develop an explanation to answer the lesson question: How can technology help reduce our waste?

This lesson could be one in a series of lessons building toward the following:

5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.

3-5-ETS1-2. Generate and compare possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
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