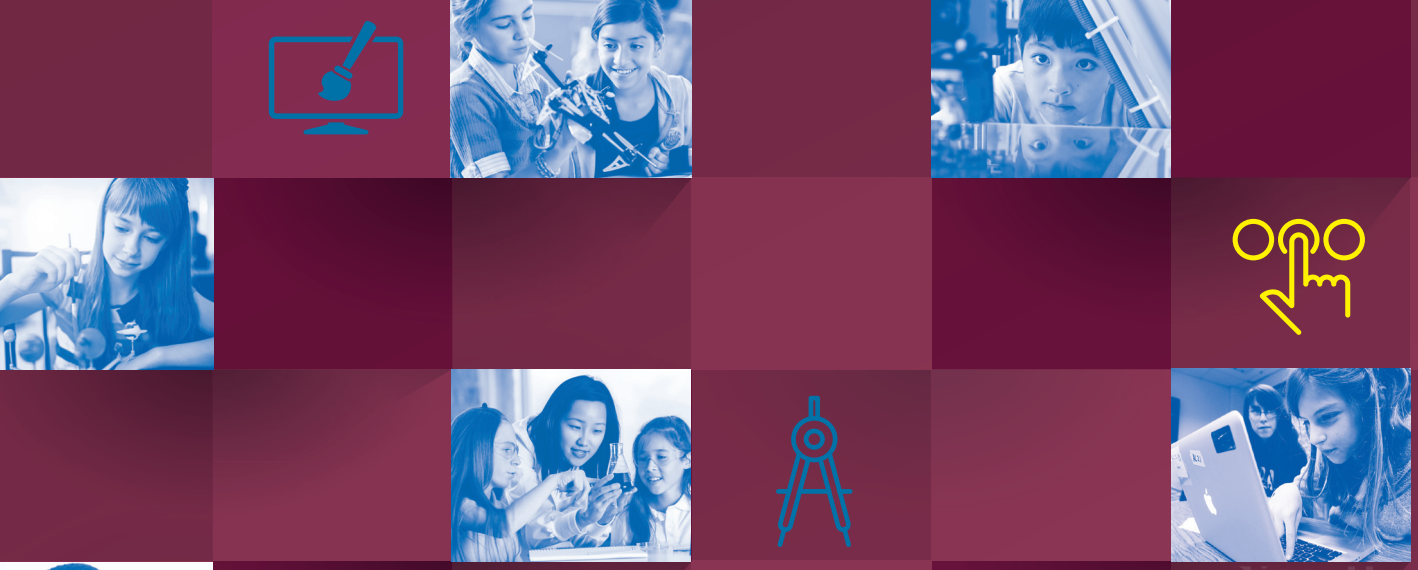

THE SUPPLY CHAIN AND LEAN MANUFACTURING

STEM²D Topic:
Manufacturing

Target Population:
Students, ages 11-14

The Supply Chain and Lean Manufacturing is part of the STEM²D **Student Activities Series**. Developed by FHI360 and JA Worldwide as part of Johnson & Johnson's WiSTEM²D initiative (**W**inning in **S**cience, **T**echnology, **E**ngineering, **M**athematics, **M**anufacturing, and **D**esign), the series includes more than 10 interactive and fun, hands-on activities for youth, ages 9-18 globally.

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THE SUPPLY CHAIN AND
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STEM²D Topic: Manufacturing
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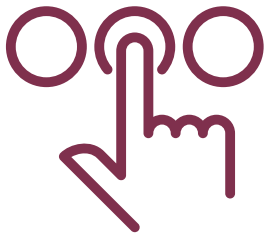


ACTIVITY DESCRIPTION

Through a team-based, hands-on activity, students will learn about the manufacturing process. Using critical thinking and problem-solving skills students will evaluate a supply chain and apply "lean principles" to make it work more efficiently.

ESTIMATED TIME

This activity typically takes **75 minutes** to complete and should be done in one session.

STUDENT LEARNINGS

STEM²D Discoveries

Students will:

- Explore the supply chain and the manufacturing process; apply "lean principles."
- Participate in a team-based learning experience.
- Learn how STEM²D—science, technology, engineering, mathematics, manufacturing, and design—subjects are involved in how companies manufacture products.
- Build important STEM²D skills, such as collaboration, creative thinking, and problem solving.
- Recognize that STEM²D offers diverse and exciting career opportunities.
- Learn about STEM²D careers.
- Have fun experiencing STEM²D.

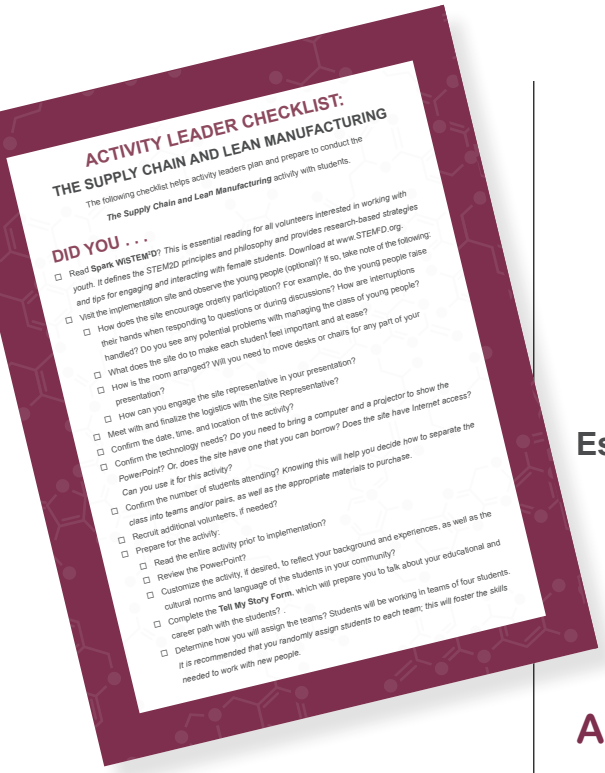
GETTING READY

Materials

- Computer with projector, speakers, and Internet access
- PowerPoint: The Supply Chain and Lean Manufacturing
- Activity Leader Checklist

STEM²D Skills

- Communication
- Creative Thinking
- Critical Thinking
- Drawing Conclusions
- Problem Solving



ACTIVITY LEADER CHECKLIST:

THE SUPPLY CHAIN AND LEAN MANUFACTURING

The following checklist helps activity leaders plan and prepare to conduct the ***The Supply Chain and Lean Manufacturing*** activity with students.

DID YOU . . .

- ☐ Read **Spark WiSTEM²D**? This is essential reading for all volunteers interested in working with youth. It defines the STEM2D principles and philosophy and provides research-based strategies and tips for engaging and interacting with female students. Download at www.STEMD.org.
- ☐ Visit the implementation site and observe the young people (optional)? If so, take note of the following:
  - ☐ How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems with managing the class of young people?
  - ☐ What does the site do to make each student feel important and at ease?
  - ☐ How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
  - ☐ How can you engage the site representative in your presentation?
- ☐ Meet with and finalize the logistics with the Site Representative?
- ☐ Confirm the date, time, and location of the activity?
- ☐ Confirm the technology needs? Do you need to bring a computer and a projector to show the PowerPoint? Or, does the site have one that you can borrow? Does the site have Internet access? Can you use it for this activity?
- ☐ Confirm the number of students attending? Knowing this will help you decide how to separate the class into teams and/or pairs, as well as the appropriate materials to purchase.
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity:
  - ☐ Read the entire activity prior to implementation?
  - ☐ Review the PowerPoint?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the **Tell My Story Form**, which will prepare you to talk about your educational and career path with the students? .
  - ☐ Determine how you will assign the teams? Students will be working in teams of four students. It is recommended that you randomly assign students to each team; this will foster the skills needed to work with new people.

- Activity Leader Handout, *1 copy per team*
- Tell My Story form
- Student Handout, *1 copy per student*
- Legos, *large box of Lego bricks in various colors and sizes*; (see Student Handout for specific requirements)
- Timer or Stop Watch

Estimated Materials Cost:

Activity leaders can expect to incur $40.00 - $50.00 in materials costs (if purchasing the Legos) when completing this activity with 20 students working in teams. To eliminate this cost, consider asking colleagues to borrow Legos.

Activity Leader Preparation

1. Read **Spark WiSTEM²D**. This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM²D.org.
2. Review the **Activity Leader Checklist** (at the end of this document) for details and specific steps for planning, preparing, setting up the venue, and implementing this activity.
3. See the **STEM²D Student Activities Overview** for additional information.

STEP-BY-STEP INSTRUCTIONS: THE SUPPLY CHAIN AND LEAN MANUFACTURING

1. Welcome and Introductions (5 minutes)

- Start the PowerPoint.
- Welcome the students.
- Tell the students your name, your organization/company, and your job title/occupation.
- Ask students and volunteers to introduce themselves.
- **(Today's Plan Slide)** Review the agenda. Explain that the students will learn about the supply chain and do a fun hands-on activity to simulate lean manufacturing principles.
- Indicate that they will also hear about the STEM²D careers involved in manufacturing.

2. **Career Awareness: Manufacturing and the World of Work (10 minutes)**
   - **(My Story Slides)** Talk about your educational and career path. Use the "Tell My Story" form as the basis for your remarks. Specifically, talk about:
     - When/Why you developed an interest in STEM²D and manufacturing.
     - The classes/courses you took in secondary school.
     - Your postsecondary path, including the institution you attended and your degree. *If you switched disciplines, make sure you explain why*.
     - What your current position entails. *Be sure to include how you use STEM²D and what you do on a typical work day*.
   - Weave in facts about manufacturing and STEM²D careers:
     - Tell the students that your career is only one of the many careers available in the **STEM²D** disciplines—science, technology, engineering, mathematics, manufacturing, and design.
     - Explain that STEM²D careers are **high-demand, high-growth careers** and are predicted to remain in demand over the next 10 years.

3. **Content Presentation: Learning About the Supply Chain (10 minutes)**
   - **(What Is a Supply Chain? Slide)** Show the images of the smartphone, tablet, and other technologies. Encourage students to reflect on how complicated it is to produce an object. Say:
     - Every item has an origin, a story.
     - Think about the things you use every day—the things you couldn't do without.
     - Tell me, how does something, such as a smartphone or tablet, go from an idea to an object that you use?
   - Students may mention things like: "Someone needed to invent it," or "I bought it from the store." Students may or may not mention the manufacturing process.
   - Introduce the topic of manufacturing, consider saying:
     - It's not as simple as inventing a product and having that product show up in stores.

KEY WORDS

- **STEM²D**
- **High-demand, high-growth careers**

KEY WORDS

- Deliver
- Make
- Plan
- Procure
- Quality control
- Return
- Source
- Supply chain

TIPS FOR WORKING WITH STUDENTS:

- Tailor your remarks to meet student needs. Feel free to modify the language, examples, and analogies.
- Frequently check for understanding by asking open-ended questions to encourage student engagement, such as “Can someone summarize the five links in a supply chain?”

    - There is an important middle step that is often forgotten: how things are physically made and distributed.
    - An efficient manufacturing process is key for companies and for consumers. If a product is too difficult or too costly to make, it is unlikely that you will ever have a chance to buy it or use it.
    - This is what we will talk about today.
- **(Links of a Supply Chain Slide)** Define the supply chain. Indicate:
    - Products get to your door thanks to something called a **supply chain**.
    - A supply chain is a sequence of events that takes an idea and turns it into a physical object.
    - There are five steps or “links” in a supply chain: plan, source, make, deliver, and return.
- Explain that the Supply Chain involves:
    - **(Supply Chain Link 1: Plan Slide)** The first link in a supply chain is **plan**. Planning involves asking questions to figure out what materials are needed and what needs to be done. Key questions include: What is the product? How many units of this product will people buy? What raw materials are needed to make one unit? To make 1,000 units? How long should it take to make?
    - **(Supply Chain Link 2: Source Slide)** The second link is **source**. Sourcing is where you procure (purchase or obtain) the materials needed to make the object. This might mean buying raw materials, such as rubber, wood, or steel, or pre-made materials, such as computer chips.
    - **(Supply Chain Link 3: Make Slide)** The third link in a supply chain is **make**. This is the step where products are built; “making” may involve individual construction or assembly lines to build the product.
    - **(Supply Chain Link 4: Deliver Slide)** The fourth link is **deliver**. Delivery involves shipping the products—by truck, ship, plane, or another delivery method—to a location, usually a retailer.
    - **(Supply Chain Link 5: Return Slide)** The last link in the supply chain is **return**; this step doesn’t always happen—it

only occurs when customers don't like the product for whatever reason and send it back—but companies must have ways to take the product back through the supply chain.
    - For example, if the customer simply returned a working, but unwanted item, the company can resell it. In this case, the product is moved to the "deliver" link in the chain.
    - In other cases, when the customer has returned something that doesn't work properly, the company may repair the item and resell it. This is essentially returning the item to the "make" link of the supply chain.
    - Or, the returned product may to be taken apart; this would involve moving the pieces to the "source" link of the supply chain.
- Ask students if they have seen a supply chain in action. For example, students may have returned products, experienced the supply chain at work in an after-school job, or had an internet order delivered to their home. As students provide examples, prompt them to identify the appropriate link in the supply chain.
- **(A Supply Chain in Action Slide)** Show the example of Janssen's supply chain. Indicate that supply chains for large companies can be very complex and challenging.

4. **Learning Activity: The Supply Chain Challenge (15 minutes)**
    - **(The Supply Chain Challenge Slide)** Introduce the challenge. Indicate:
        - Today, we are going to do an activity that simulates a supply chain and will require you to evaluate the supply chain and investigate how to make it work more efficiently.
    - **(The Supply Chain Challenge Directions Slide)** Provide the directions:
        - Our company recently received an order for a large number of cars for immediate delivery.
        - Your team is tasked with building six (6) cars using the Legos on the table.
        - Each engineer on the team must make his/her own car.
        - Each car must pass **quality control**—this means the car cannot have any mistakes and must perfectly match the instructions.

➤The fourth of the five links in the supply chain process is delivery. Delivery involves shipping the products—by truck, ship, plane, or another delivery method—to a location, usually a retailer or directly to your home.

TIPS FOR WORKING WITH STUDENTS:

- Make sure to use your phone or stop watch to time the teams.
- Be strict with the time limit, students should feel pressure to complete the cars.
- It is important not to give the students time to prepare prior to building the cars. Preparation is a key component of Round Two!

- Once an engineer finishes a car, she or he places it in the "done basket," which is the **Activity Leader Handout** located in the center of each table.
- Teams will be timed to see how fast all six cars can be assembled. Teams will have a maximum of five minutes to complete production.
- The **Student Handout** provides detailed instructions for building the cars.
- Ready, get set, go!

- **(What Did We Learn? Slide)** After 5 minutes, call time. Debrief the activity by asking:
  - How many cars did your team produce? How long did it take?
  - Did all the cars meet quality standards?
  - What went well? What didn't go well?
  - What supply chain "links" did you see in action?
- During the debrief, be sure to review the main points of the challenge. Talk about how the activity simulates each of the five links in the supply chain. If answers are not forthcoming, point out that the printed instructions are the **plan** link; reaching for the Legos is the **source** link; building the cars is the **make** link; depositing the fully-assembled cars in the "done" basket represents the **deliver** link; and cars that did not meet quality standards and were rebuilt, represent the **return** link.

KEY WORDS

- Lean manufacturing
- Waste
- One-piece flow

5. **Content Presentation: Making Things Lean (15 minutes)** Introduce lean manufacturing principles.
   - **(Making Things *LEAN* Slide)** Indicate:
     - Lean manufacturing is a practice that eliminates waste from the manufacturing process.
     - **Waste** is anything the customer doesn't value.
     - Companies use a variety of tools to eliminate waste and be lean, such as:
       1. Producing only what is needed; and
       2. Implementing **one-piece flow** (producing the parts you need one at a time, in a natural flow).
       3. Using visual aids to remind people of how to do things.

- **(The 8 Wastes Slide)** Indicate that there are 8 major wastes and lean manufacturing seeks to eliminate all of them. The 8 wastes are:
  - **Waiting:** The time workers spend without anything to do, because parts are held up.
  - **Overproduction:** Making more than the customers want.
  - **Excess inventory:** Products are held in warehouses or back rooms—even when customers are willing to buy them; it costs more to transport excess materials and customers are unhappy.
  - **Defects:** When products are built incorrectly and need to be returned.
  - **Transporting:** It costs money to move things—the further the factory is from the customer or the harder it is to transport the product, the higher the cost.
  - **Unused creativity:** People have good ideas! If you don't recognize these ideas and put them into action, the innovate/planning process is harder and more costly than it needs to be.
  - **Inappropriate processing:** Occurs when the company doesn't know what the customer wants, and more time than necessary is spent giving the product unwanted features. For example, if customers do not want their cars to have racing stripes, the company shouldn't spend time and money painting racing stripes.
  - **Excess motion:** When the company has unnecessary steps in the manufacturing process. For example, excess motion is when a worker carries a part across the floor to the next station. To avoid excess motion, key questions need to be asked: Can the motion be avoided? Can we build

TIPS FOR WORKING WITH STUDENTS:

Ask open-ended questions to encourage student reflection. Try:

- Was there waste in your Supply Chain Challenge manufacturing process?
- What was the waste?
- How could your team eliminate the waste?

➤ **Overproduction is one of the 8 Wastes that manufacturers seek to eliminate with Lean Manufacturing.**

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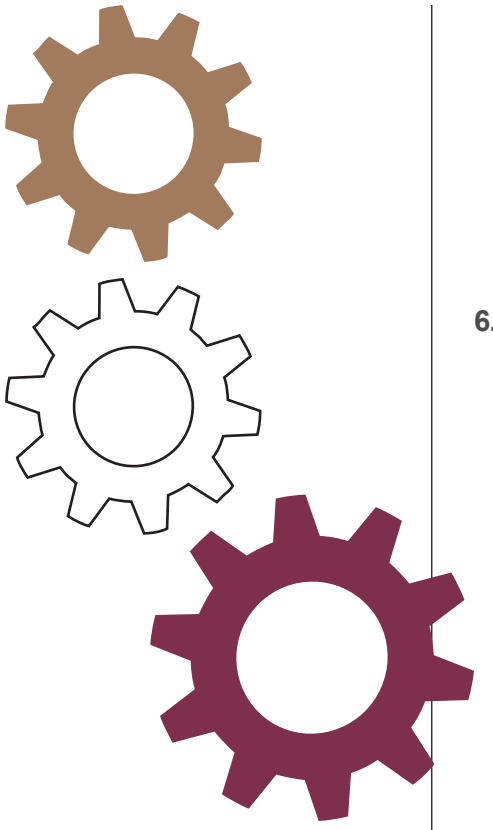

many parts on the same campus, so things don't need to be transported?

- Encourage students to reflect on the Supply Chain Challenge (building the Lego cars). Have students identify if any of the 8 wastes were present in their manufacturing process.

6. **Learning Activity: The *Lean* Supply Chain Challenge (15 minutes)**
   - **(The *Lean* Supply Chain Challenge Slide)** Introduce the second learning activity. Teams will again complete the original challenge, this time using "lean manufacturing principles." Give the following directions:
     - In this challenge, each team will attempt to streamline its supply chain by using lean manufacturing principles. Be sure to keep the 8 wastes in mind!
     - This time, instead of each engineer building an entire car, the team will employ the "one-piece flow tool" and use an assembly line to, hopefully, make the team more efficient.
     - In an assembly line, each engineer produces one piece of the car and passes it to the next engineer to further assemble the car.
     - One team member must be a "quality assurance officer" and make sure that each car is built properly.
     - Teams have three minutes to figure out the assembly line process—who's doing what—and set up their stations.
     - Teams have five minutes to produce the cars.
   - **Do NOT** tell teams how many cars to make. The instructions only indicate that there is a demand for cars; some teams may assemble more than the six (6) cars required in the original challenge.
   - Start the timer.
   - Give teams two warnings; the first with 1-minute remaining, and the second with 30-seconds remaining before the prep time ends.
   - After 3 minutes, call time. Start the clock for the 5 minutes of production. Say:
     - Alright, now that we've completed planning, we're moving into production!
     - Ready, set, go!
   - Strictly adhere to the time limits.

- **(What Did We Learn? Slide)** After 5 minutes, call time and debrief the activity. Ask:
  - How was this different than the first challenge? Did it go better? Worse?
  - Did the preparation time make a difference? How?
  - Which of the 8 wastes did your team identify and eliminate in its assembly line?
  - How could your team improve? Eliminate more waste?
  - How many cars did your team produce in 5 minutes?
  - Is that a waste?
  - What about those extra Legos . . . Are they a waste?

7. **Recap (2 minutes).**
   - **(Lean Gone Wrong Slide)** If time permits, show the "I Love Lucy" video. This is a funny video aimed at helping students reflect on the lean principles and the 8 wastes.

8. **Student Reflection (3 Minutes)** Spark a large group discussion and/or written reflection.
   - **(Being Lean Slide)** Review the key concepts from the activity.

TIPS FOR MAKING CONNECTIONS:

- Convey that STEM²D is an exciting and dynamic pathway that can open options for a variety of future careers; depending on where their interests lie, students can opt for one of hundreds of different careers.
- Many STEM²D occupations require additional education and training, such as a a bachelor's degree. More technical and advanced jobs, including those in research, usually require an advanced degree, such as a master's or doctoral degree.

➤ In an assembly line, each engineer produces one piece of the car and passes it to the next engineer to further assemble the car.

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- Indicate that the lean principles apply to our daily lives.
- Ask:
  - How can we apply lean manufacturing to our daily lives?
  - What can we do to avoid the 8 wastes in our daily lives?
- **(Being Lean in Life Slide)** Have students read the examples. Ask:
  - Which example(s) will you implement?
  - Are there other ways you can be lean and avoid waste?
- Thank the students for joining you today.
- Encourage the students to continue exploring careers in STEM²D. Reassure them that they can do STEM²D.

KEY WORDS

Supply Chain: The sequence of processes involved in the production and distribution of a commodity. The five links of the supply chain include:

- **Plan:** planning how to make the product and how much of it is need.
- **Source:** obtaining raw materials for the product.
- **Make:** manufacturing the product.
- **Deliver:** transporting the product to customers.
- **Return:** taking back defective or unwanted products or putting them back into the supply chain.

Lean Principles: A set of principles that people use to achieve improvements in productivity, quality, and lead-time by eliminating waste. Includes:

- **One Piece Flow:** the method of production in which operators or machines work on single units and pass them along to the next process when requested.
- **8 wastes:** Common ways the manufacturing process loses time and money. These include:
  1. **Waiting:** the time workers spend without anything to do, because the process is held up.
  2. **Overproduction:** when more product is produced than the customers want.
  3. **Excess inventory:** when too much of the product is held in storage.
  4. **Defects:** when products are built incorrectly and need to be returned.

5. **Transporting:** moving products (or resources) from one place to another.
6. **Unused creativity:** not using an employee's good ideas or full potential.
7. **Inappropriate processing:** spending time on things that are not needed or wanted.
8. **Excess motion:** movements that do not need to be done to accomplish the goal.

Activity Leader Reflections

After the activity, take a few moments to reflect on the following:

- What went well and what could be improved? What would you do differently next time?
- How comfortable did you feel talking about manufacturing and the supply chain?
- Do you have a better understanding of STEM²D concepts?
- How useful was the information presented in **Spark WiSTEM²D** to implementing this activity?
- Will you volunteer for this type of experience again?

Resources and References

- Adapted from an activity developed by Janssen volunteers from the Johnson & Johnson BTE-Bound Brook, New Jersey program.

➤ **Excess inventory can be avoided with lean manufacturing.**

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ACTIVITY LEADER CHECKLIST:

THE SUPPLY CHAIN AND LEAN MANUFACTURING

The following checklist helps activity leaders plan and prepare to conduct the ***The Supply Chain and Lean Manufacturing*** activity with students.

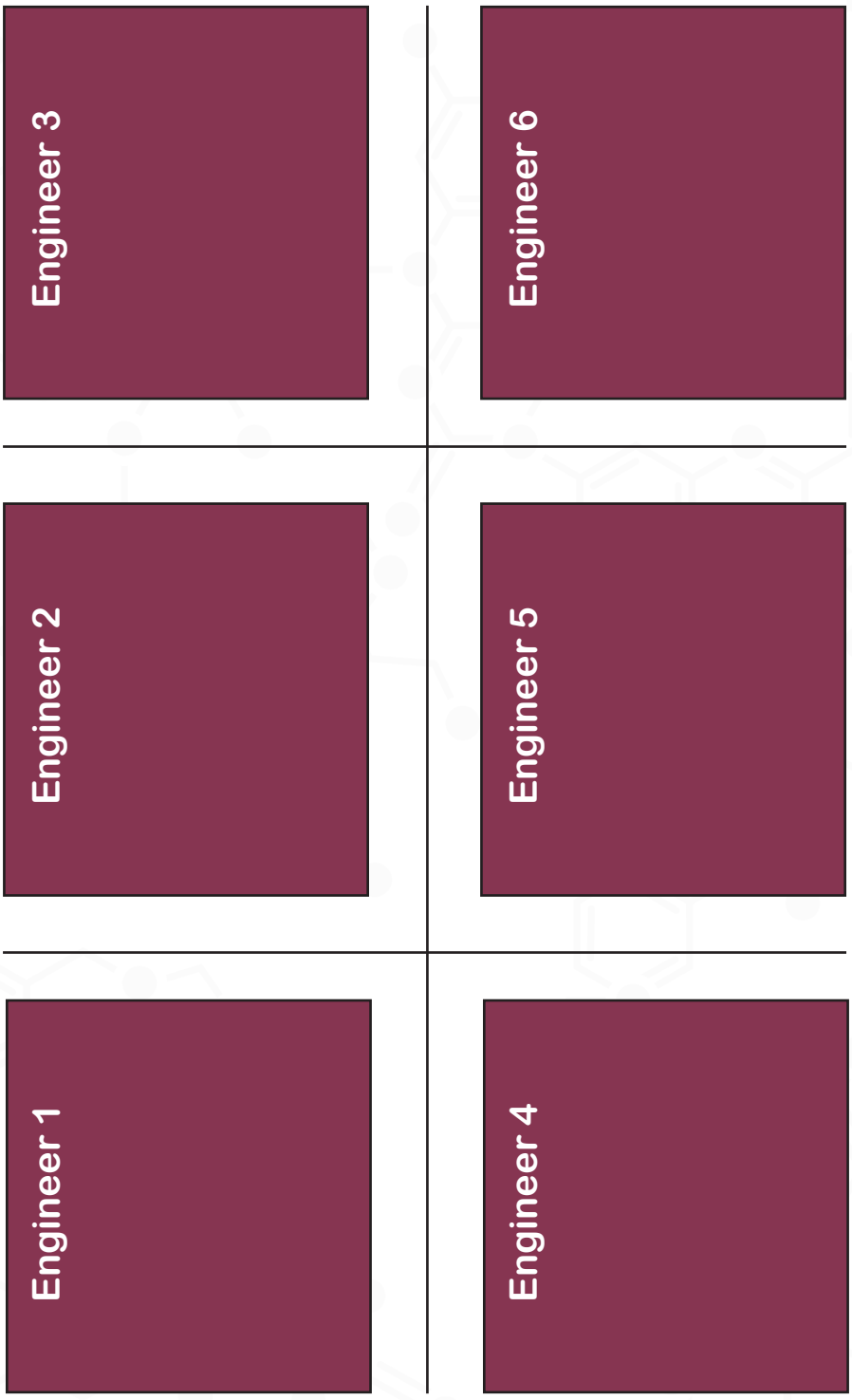
DID YOU . . .

- Read **Spark WiSTEM²D**? *This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM²D.org.*
- Visit the implementation site and observe the young people (optional)? If so, take note of the following:
  - How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems with managing the class of young people?
  - What does the site do to make each student feel important and at ease?
  - How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
  - How can you engage the site representative in your presentation?
- Meet with and finalize the logistics with the Site Representative?
- Confirm the date, time, and location of the activity?
- Confirm the technology needs? *Do you need to bring a computer and a projector to show the PowerPoint? Or, does the site have one that you can borrow? Does the site have Internet access? Can you use it for this activity?*
- Confirm the number of students attending? *Knowing this will help you decide how to separate the class into teams and/or pairs, as well as the appropriate materials to purchase.*
- Recruit additional volunteers, if needed?
- Prepare for the activity:
  - Read the entire activity prior to implementation?
  - Review the PowerPoint?
  - Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - Complete the **Tell My Story Form**, which will prepare you to talk about your educational and career path with the students? .
  - Determine how you will assign the teams? You will need at least six students per team. *It is recommended that you randomly assign students to each team; this will foster the skills needed to work with new people.*

- Practice your presentation, including the hands-on, minds-on activity? Be sure to:
  - Do the activity; make sure you can explain the concepts to students, if needed, and that you know the correct answers.
- Obtain the required materials (*see the **Materials** and **Estimated Materials Costs** sections*)?
- Prepare the space:
  - Assign each team (of 6 students) to a table.
  - Distribute Legos to each table – enough pieces to make 6 cars per team.
  - Print one copy of the **Activity Leader Handout** for each team and place it in the center of the table.
  - Print the **Student Handout**: one copy per student and place 6 copies on each table.
- Bring a camera, if desired, to take photographs.
- Obtain and collect permission slips and photo release forms for conducting the activity, if applicable?
- **Have fun!**

Activity Leader Handout

DONE BASKET



Tell My Story Form

This form will help volunteers serving as activity leaders prepare to talk about their **STEM²D** interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

Company: _____

When/Why did you become interested in STEM²D? _____

_____

_____

What do you hope young people will get out of this activity? _____

_____

FUN FACT

Share a little about your background. Ideas:

- Share a memory from childhood where you first had your 'spark' or 'interest' in STEM²D.
- Detail your journey; highlight what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most?

_____

_____

How did you know you wanted to pursue a STEM²D career?

_____

_____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why to the students.*

_____

_____

What your current position entails. *Be sure to include how you use STEM²D on a typical work day.*

_____

_____

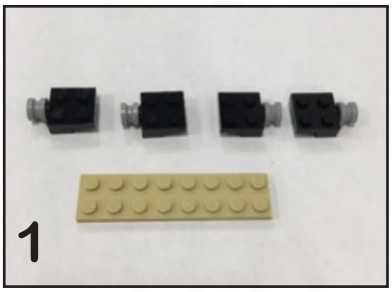
_____

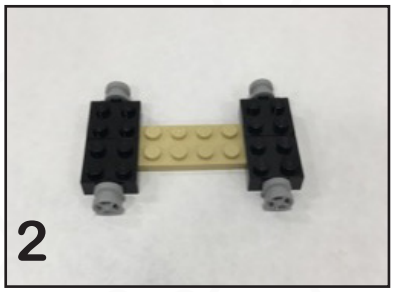
THE SUPPLY CHAIN CHALLENGE!

Student Handout

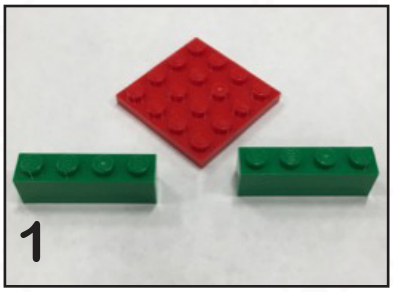
Challenge Instructions:

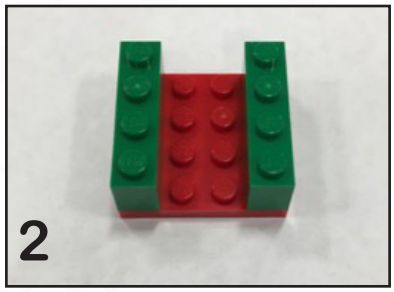
Step 1: Assemble the wheels on either side of the main axle, (see images):

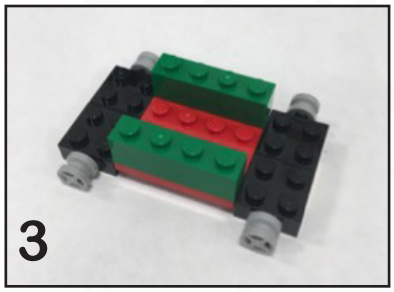




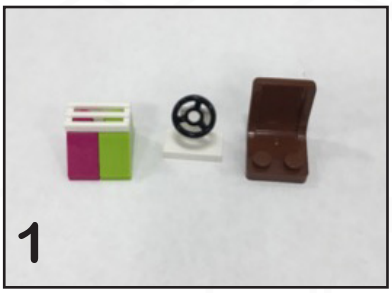
Step 2: Make the body of the car by placing the long pieces on both sides of the flat piece. Next place the body on the axle **(Step 1)** between the wheels (see images).

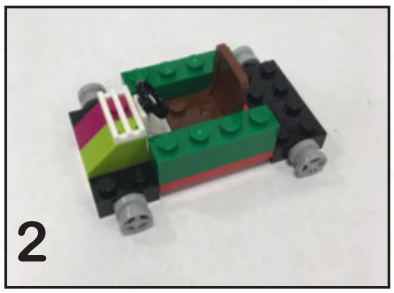




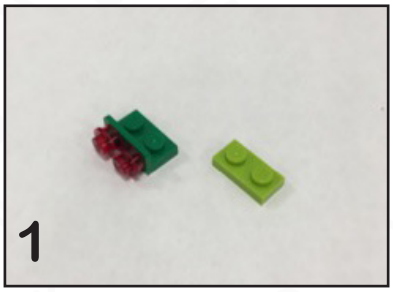


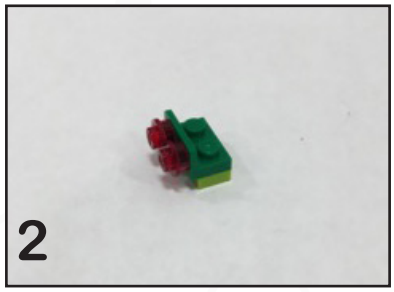
Step 3: Take the triangular pieces that include the grated piece, and place them on either end of the car (front). Add the seat and steering wheel to the car (see images).

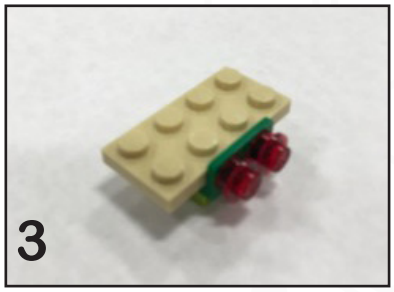


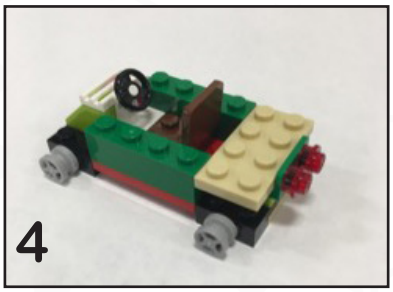


Step 4: Put the L-shaped piece with the tail lights on top of the other small piece. Attach the flat piece on top of the L-shaped piece to make the car's spoiler. Complete the body by attaching the spoiler to the back of the car.

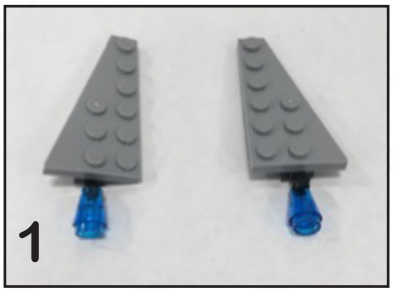


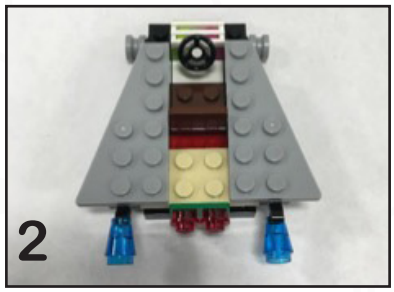






Step 5: Place the wings on the car (see images).





Step 6: Check to make sure the car is assembled correctly and will pass quality control. Deposit completed car in the "Done Basket."

Content courtesy of Johnson & Johnson, FHI360, JA Worldwide,
and Smithsonian Science Education Center.
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