SIEMENS STEM DAY | Science Technology Engineering Math

GRADES 9–12

SIEMENS STEM DAY ACTIVITY

SYSTEMS THINKING

OBJECTIVES

Students will be able to:

- Apply systems thinking by analyzing an engineering or science-based concept/phenomenon.
- Demonstrate an understanding of the dynamics of circular cause and effect within a causal loop design.
- Illustrate connections within a system and their corresponding behaviors.
- Identify how a change in connections can cause changes to the system.

THIS LESSON FOCUSES ON

Engineering Design Cycle

- Defining the Problem
- Designing Solutions
- Communicating Results

21st-Century Skills

- Communication
- Critical Thinking
- Creativity

OVERVIEW

Students will understand the importance of causal loop diagrams in order to make meaningful connections within a system. By looking at the critical components of a system, students will learn how to analyze the interdependence needed for optimal systems operations. This application of flexible thinking will encourage students to further consider how each action within a system impacts the next.

STEM incorporates Science, Technology, Engineering, and Mathematics to focus on real-world issues and problems guided by the engineering design process. This type of instruction supports students in developing critical thinking, collaboration, reasoning, and creative skills to be competitive in the 21st-century workforce.

Each Siemens STEM Day classroom activity highlights one or more components of the engineering design cycle and an essential 21st-century skill.

MATERIALS

- **Causal Loops Basics** Handout—one per person
- **Sample Causal Loops** Diagrams—visually project or digitally share
- Large blank paper—one per pair
- Sets of markers—one set per pair
- Timer
- Computers with internet access

HAVE YOU EVER WONDERED . . .

How to best approach complex problems?

NATIONAL STANDARDS

Standards for Technology Literacy	Standard 3: Students will develop an understanding of The Nature of Technology. This includes inquiring a knowledge of the relationship among technologies and the connections between technology and other fields. Standard 4: Students will develop an understanding of Technology and Society. This includes learning about the cultural, social, economic, and political effects of technology. Standard 13: Students will develop Abilities for a Technological World. This includes becoming able to assess the impact of products and systems.
Next Generation Science Standards	HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety reliability, and aesthetics as well as possible social, cultural, and environmental impacts. SEP1: Asking Questions and Defining Problems. SEP2: Developing and Using Models.

MAKE CONNECTIONS!

How does this connect to students?

Systems thinking can be used by students as a framework to creatively **examine complex problems** in new ways. Practice with systems thinking helps students to make meaning of their learning and experiences both in and out of the classroom. Four commonly used systems thinking tools include causal maps, feedback loops, behavior over time, and collect and cluster to identify patterns.

How does this connect to careers?

A **systems engineer** is responsible for leading a team in problem solving within complex systems. This role embraces the concept that the whole is greater than the sum of its parts. Systems engineers not only address the causations and changes within a system, but also consider how different systems affect one another.

How does this connect to our world?

Causal maps are used in business, manufacturing, engineering, and many other fields to show multiple relationships and causations within systems.

Problem solving and critical analysis are fundamental skills required in every industry at every career level. Employers seek out and value candidates who demonstrate strong analytical problem-solving skills.

BLUEPRINT FOR DISCOVERY

1. Depending upon your familiarity with systems thinking and more specifically causal loops, you may wish to review some of these resources before beginning this lesson:
    - Systems Thinking! https://www.youtube.com/watch?v=GPW0j2Bo_eY
    - Design Pack Systems Thinking https://educators.brainpop.com/wp-content/uploads/2014/07/IOP_QDesignPack_SystemsThinking_1.0.pdf
    - Introduction to Causal Loops https://www.youtube.com/watch?v=tTo06jbSZ4M&t=33s
    - System Archetype Basics https://thesystemsthinker.com/wp-content/uploads/2016/03/Systems-Archetypes-Basics-WB002E.pdf
2. To engage students in what they will be learning, show the *What is Systems Thinking?* video https://www.youtube.com/watch?v=FW6MXqzeg7M. After watching, facilitate a conversation about systems thinking.
3. Causal loops are used to visually demonstrate systems thinking.To acquaint students with this concept, instruct students to read "Causal Loop Construction: The Basics" and "Fine-Tuning Your Causal Loop Diagrams—Part 1." Distribute the **Causal Loops Basics Handout** and instruct the students to take notes as they read the articles. https://thesystemsthinker.com/causal-loop-construction-the-basics/

https://thesystemsthinker.com/fine-tuning-your-causal-loop-diagrams-part-i/

4. Engage students in a discussion of what they learned about creating causal loop diagrams. Encourage students to share what they found interesting and confusing about what they learned.
5. Visually project the **Sample Causal Loop Diagrams** and ask students to make observations of what they see in each diagram. Be sure to address the importance of the direction of the arrows and the use of + and –.
6. Tell the students to find a partner who they would like to work with during the next task. Distribute one large sheet of paper and a set of markers to each partner set. Instruct them to select an engineering or science topic of their choice and create a causal loop diagram. Explain to the students that they will later share their diagrams with their classmates. Provide ample time for students to complete this activity.
7. Explain that the students will next participate in a Partner-Pair-Share. Ask students to find another partner set and instruct them to share and discuss each of their diagrams. Allow students to share for 2–3 minutes, and then announce that they need to rotate and find a different partner set. Again allow 2–3 minutes of share time, and then repeat this process a few more times depending upon the amount of time available.
8. Conclude the lesson by what students have achieved to identify the advantages of using systems thinking and causal loop diagrams. Also ask students to identify how a change in connections can cause changes to the whole system. Encourage them to provide examples from their learning as support.

TAKE ACTION!

Students can use an online diagram software called Visual Paradigm to create a digital causal loop diagram. This is a free online resource that provides access to a variety of diagram templates. https://online.visual-paradigm.com/

CAUSAL LOOPS BASICS

https://thesystemsthinker.com/causal-loop-construction-the-basics/
https://thesystemsthinker.com/fine-tuning-your-causal-loop-diagrams-part-i/

Read these two articles "Causal Loop Construction: The Basics" and "Fine-Tuning Your Causal Loop Diagrams —Part 1." Take notes on the key details below.

Create Variable Names	**Draw the Links**
Label the Loop	**Talk Through the Loop**
Reinforcing or Balancing?	**Causation Rather Than Correlation**

SAMPLE CAUSAL LOOPS DIAGRAMS

Figure 1—Education

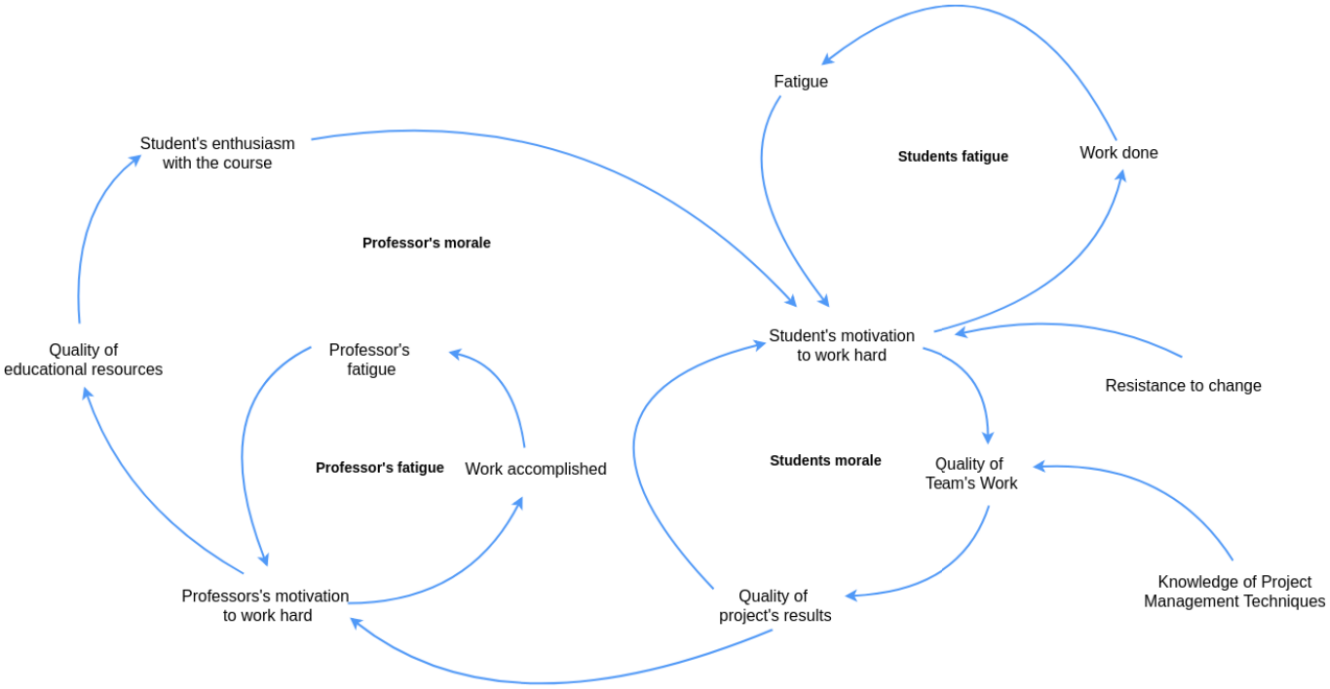
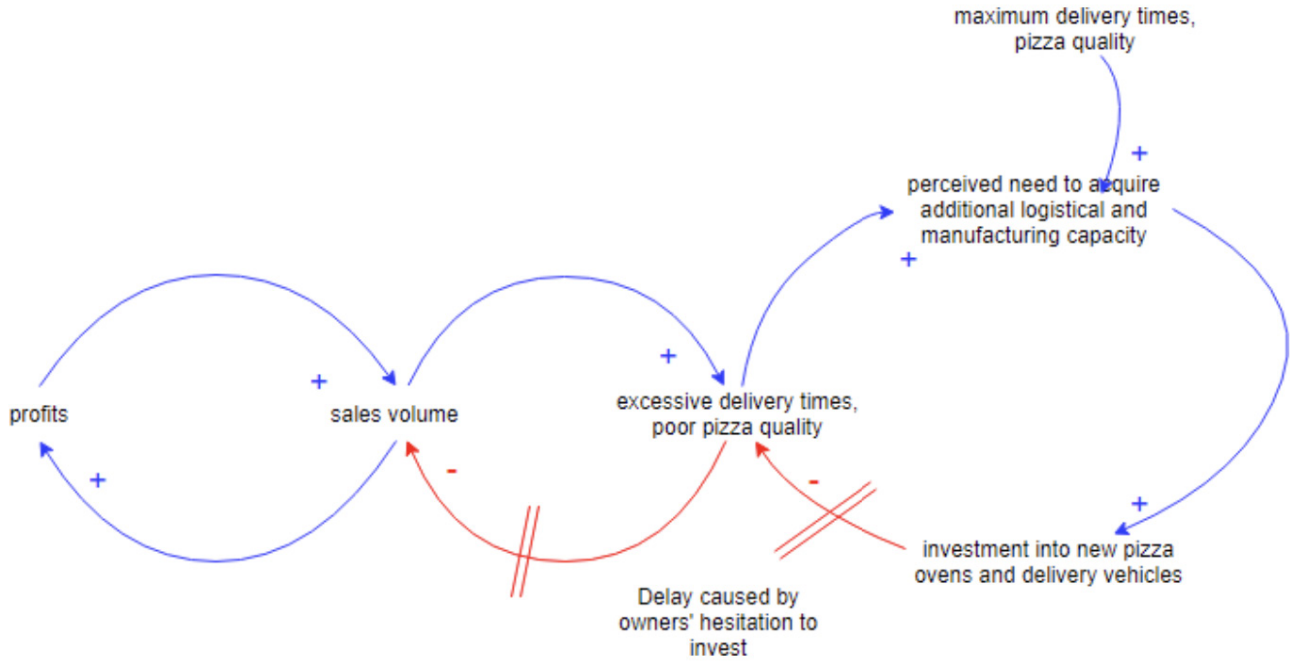


Figure 2—Pizza



https://warren2lynch.medium.com/system-thing-with-casual-loop-diagram-learn-by-examples-61dabdc4cdd