Lesson 4: The Internet

High School Cybersecurity Unit: Code for Change

Lesson Overview	Career Highlight
Nearly five billion people, about two-thirds of the global population, have access to the internet. The Internet of Things, comprising our smart devices, are all part of this massive system. In previous lessons, students learned about managing and protecting their online activity. In this lesson, they will learn what the internet is and how the internet works. Even though most devices transmit data wirelessly, eventually people must go through the wires of the internet. It is a global physical system supported by computing and storage resources that are housed at data centers. The United States alone has nearly 3,000 data centers. Some of the most important issues (net neutrality and internet censorship) faced by society hinge on an understanding of the internet. To have an informed opinion though, it helps to understand the technical underpinnings of how the internet works. The goal is for students to understand the physical structure of the internet at a high level.	Depending on the level of security at a specific data warehouse, many locations will keep most positions for the facility in-house. These would include the jobs directly related to: ● Data storage ● Digital security ● Physical security ● Facilities engineering, cleaning, maintenance ● Mechanical engineering ● Network engineering ● Many others!

STEM Course Connections	Timing
Math: Network science is a research field. Networks are a mathematical description of a complex system composed of many interacting components, including (electrical) power grids, (biological) ecosystems, (social) friendships, and (biological) neural networks. Science: Patterns, structure, systems. Computer Science: The internet is an information network. It contains many nodes (points of connection) interacting in many different ways. Sociology: In a social network (sociology), the nodes are people and the connections are friendships. Biology: Networks define patterns in nature like the food chain, bacteria, locusts, fish, and starlings.	Five classes at 45 minutes each

Engineering Activity

Science and Engineering Practice #	Students will create a physical model of the internet using strings and physically moving in the classroom, participate in a demonstration using interactive binary cards, make their own secret message by encoding using Unicode, create a special character for their app, explore a virtual data center, and physically redesign a data center using materials provided by the teacher.

Essential Questions

1. What happens when you click on a browser link to go to a webpage?
2. How is information sent and received?
3. What is the internet and how does it work?
4. How can the ASCII language be used to explain data transfer between digital devices/computers?
5. Why are there data breaches and what does this mean for us?
6. What are bits? What are bytes?

Lesson Objectives

Students will be able to:

- Visualize the system that we call the internet.
- Use symbols to send secret messages.
- Investigate a major facility that manages data used by the internet.
- Consider the impact of data breaches on their personal security.

Materials

All materials in Student Handouts, unless otherwise noted.

- Routers Image
- Enough pieces of string or yarn for each student to have about two pieces, each about a foot in length
- Bits, Bytes and Data Packets (answer key)
- Unicode Encoding Table
- Data Packet
- Virtual Tour of a Data Center (student example)
- Data Center Redesign Rubric
- Index cards
- 9 x 13 posters

Lesson

Teacher Note: For some background on the internet. Data in computers is stored and transmitted as a series of zeros and ones. Digital signals have only two values: off (0) and on (1). Information on the internet is sent in packets. These packets are sent as digital signals along electrical wires. See the A Packet's Tale. How Does the Internet Work? video for more information. The internet is a physical network of computers, connected by data transfer cables. It is a global physical system supported by computing and storage resources that are housed at data centers. See the Andrew Blum: What is the Internet, really? video for more information.

Day One: Visualize the Internet.

- **Individuals: Hook (10 minutes)**

- Ask for students to draw a picture on a 9 x 13 poster of what they think the internet looks like. Save the posters because students will be drawing again at the end of the lesson.

- Set a timer for 10 minutes. After five minutes, show some features of the internet in your classroom:
  - WiFi Access Point, if you can see it, or show students a picture of a router.
  - Nest of wires, potentially behind a ceiling tile, if you can move one.
  - Arrange with the school's IT department to take students on a tour of the school's server room or data closet.

  Teacher Note: Fun fact that your students might not know. Multiplayer games predate wireless connections and internet streaming. Back in the 1970s, friends would truck their computers over to someone's house and connect them together with physical wires. These gatherings were called Local Area Network (LAN) Parties. 'Local Area' means 'in the same room' while 'Network' means the devices are directly connected to each other with wires. LAN parties are still popular. The Nintendo Switch brought back the LAN party with Mario Kart 8 Deluxe, which allows eight consoles to connect over the same local network.

- **Small Groups, Activity: Create a Physical Model of the Internet (30 minutes)**
  This activity was derived from Code.org's Building a Network.

  - Ask for three students to stand at the front of the room, holding one piece of string between each pair. The string represents a single wire that the students can use to communicate with each other. Ask students: Imagine this was the internet. Can you see any potential problems?
    - Direct the conversation towards the need to be able to talk to multiple people and the need to have a backup if that wire is damaged or unable to transmit information.

  - Tell students that in today's activity, they will build a representation of the internet to address some of these concerns.

  - Place students in groups of five to seven. Challenge students to build a computer network that allows them to connect with multiple people. Remind students that they are only allowed to speak to another in their group if their connection can be traced through a string,, and that only two people can be connected by a single string.
    - Set a timer for 3 minutes for each round.
    - Each round keeps the rules of the previous one.

  - Round 1: Give each group access to as many pieces of string as they like. (Alternatively, give each group a ball of yard and a pair of scissors for them to cut their own.)

  - Round 2: Tell students that strings cost money. Which group can connect the most people with the fewest strings?

  - Round 3: Tell students that strings can be cut. Challenge them to create a network that will maintain itself even if one string is cut.

  - Round 4: Tell students that direct connections are faster than long paths with indirect connections. Can they find a way to balance this fact with the fewest strings possible? (Give students a few extra minutes with this round to find their optimal balance.)

- **Whole Group: Wrap up (5 minutes)**
    - Ask for a few groups to share their strategy for Round 4. There are many ways to complete this challenge, so how did they approach it? What is a strength of their network, and what is a weakness of it?

    - Ask for students to draw their networks on paper, and save these drawings next to the first drawings of the day for comparison throughout the lesson.

    - Ensure students made the following connections from the day's activity:
        - Each individual person was a computing device.
        - The strings were the paths between devices.
        - The entire system - devices and paths - make up a computer network.

Day Two: Encoding and Decoding Text

- **Individual (45 minutes)**
    - Have students walk through the Bits, Bytes and Data Packets Student Handout, which ends with them sending a binary code to a classmate, and translating a binary code from a classmate. This handout will have them watch the video How to convert between decimal and binary (6:30). They will also need the Unicode Encoding Table and the Data Packet Student Handouts to complete this activity.

    - For students who get done quickly, there is an extension activity for students to apply binary to understanding how a 64-bit image would be transmitted.

Day Three: Data Center Investigation, Part One

- **Whole Group: What is a Data Center? (5 minutes)**
    - Show What is a Data Center? to students.

    - Tell students: "Understanding how data is stored and managed is important when building an online app. If you were to launch your app, you would need to consider how and where you were storing the information for it. Smaller organizations rent space in the cloud, and their data is physically maintained on servers at a data farm."

- **Small Group: Virtual Tour of a Data Center (35 minutes)**
    - Have students explore *We Live in a Cloud*. Remind students of Lesson 1 activity of Systems Thinking, and have them work in small groups to complete the Virtual Tour of a Data Center Student Handout. During this activity, they will generate a list of components of a data center, then sort these components into categories, and finally create a concept map to identify how the components that support a data center interact with each other.

    - The goal of this activity is for students to understand that data centers are more than warehouses of computers that run websites and apps. Students should be able to generate a concept map that includes the requirements for running a data center as well as its impact on resources, people, communities, and the environment.

- **Whole Group: Wrap up (5 minutes)**
    - Tell students that during Day 4 they will consider some potential problems to data centers and propose solutions to address them.

    - Collect the posters for safe keeping.

Day Four: Data Center Investigation, Part Two

- **Whole Group: Problems with Data Centers (10 minutes)**
    - Hang the concept maps from Day 3 up around the classroom. Have students do a Gallery Walk of the posters, looking for the PROBLEMS with data centers. Note: they are not judging other group's concept maps, but identifying problems with data centers as a whole.

    - Give students sticky notes, and tell them to spend about 5 minutes at each poster, trying to identify problems. Have students write each problem they identify onto an individual sticky note, and keep all their sticky notes.

- **Whole Group: Categorizing Problems (10 minutes)**
    - Have students work as a whole group to categorize all the problems identified among the group into a few categories (aim for five or so). This might take a leader to help direct traffic - consider nominating a student to do so.

- **Small Groups: Data Center Redesign (25 minutes)**
    - Divide the group into the same small groups as in Day 3, and have them brainstorm some solutions to address these problems. Each solution they identify should be written on a separate sticky note. Let students know that no solution is too out there and that the idea is to come up with as many creative solutions as possible, not just the practical ones.

    - Push groups to brainstorm a full 10 minutes, encouraging them to come up with all the outlandish ideas they can!

    - Once groups have completed their brainstorms, they can turn to redesign. Instruct them to select one problem and a solution to that problem. The problem they identify should be clear on their concept map. Over the rest of today and the start of Day 5, they will work to showcase this potential solution.
        - They may decide to showcase their solution in a poster, a presentation, a video, a skit, an essay, or however else they would like.
        - They should make sure their showcase explains how the solution solves the problem, the desired outcome of their solution and how it could be measured. They should also highlight who is helped by this solution.

    - Have students guide their work based on the Data Center Redesign Rubric from their Student Handouts.

Day Five: Data Center Redesign, Continued

- **Small Groups: Data Center Redesign (20 minutes)**
    - Give students a chance to finish up their work from Day 4 and prepare to present their solution to the class.

- **Whole Group: Data Center Showcase (25 minutes)**
    - Give each group 5 minutes to present their solution to the class.

CA NGSS Standards

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

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.

CTE Alignment

ST 5. Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.

ST-ET 1 Use STEM concepts and processes to solve problems involving design and/or production.

ST-ET 4 Apply the knowledge learned in the study of STEM to provide solutions to human and societal problems in an ethical and legal manner.

ST-ET 5 Apply the elements of the design process.

ST-SM 1 Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

ST-SM 2.10: Research a topic, collect data, analyze the data and draw conclusions from the results.

Resources

Binary Numbers. (2021, September 24). Classic CS Unplugged. https://classic.csunplugged.org/activities/binary-numbers/

Cybersecurity 101. (n.d.). PBS. https://www.pbs.org/wgbh/nova/labs/video_popup/5/31/

Data Centers - Our Data Centers. (n.d.). Amazon Web Services, Inc. https://aws.amazon.com/compliance/data-center/data-centers/

Gartenberg, C. (2017, February 14). *The Nintendo Switch is bringing back the LAN party*. The Verge. https://www.theverge.com/circuitbreaker/2017/2/14/14612142/nintendo-switch-local-lan-multiplayer-ethernet-adapter#:%7E:text=The%20Nintendo%20Switch%20is%20pushing,Wi%2DFi%20for%20local%20multiplayer.

Lesson 2: Building a Network. (n.d.). Curriculum.Code.Org. https://curriculum.code.org/csp-20/unit2/2/

RAFT - Resource Area for Teachers. (2021, December 18). *Free STEM cybersecurity lesson plan, deep learning, computers*. RAFT. https://raft.net/lessons/a-glimpse-into-cyber-security-2/

Statista. (2022, February 7). *Data centers - statistics & facts*. https://www.statista.com/topics/6165/data-centers/

We Live in the Cloud. (n.d.). Microsoft. https://news.microsoft.com/stories/microsoft-datacenter-tour/

What is a Data Center? (2021, February 17). [Video]. YouTube. https://www.youtube.com/watch?v=Amow8BJm5Go&feature=youtu.be

Activity 1 - Count the Dots—Binary Numbers

Routers

Image from https://www.businessinsider.com/guides/tech/best-router

Bits, Bytes and Data Packets Answer Key

4. **Converting to Binary**
   Watch the video How to convert between decimal and binary to get a good understanding of this process. You may stop the video at 6:30.

   Based on what you have learned, convert LOL into binary.

Letter	ASCII	Binary
L	76	1001100
O	79	1001111
L	79	1001100

Virtual Tour of a Data Center Student Example