Data Visualization

What Is Data Visualization?

Data visualization represents information in the form of a chart, diagram, picture, or infographic so that the data can be quickly and easily understood. Technicians use data visualization software to create graphics that communicate complex and relational information to a variety of audiences.

Vocabulary

- Dataset – a collection of data, often organized in a spreadsheet or database
- Chart – a graphic representations of data; examples are charts, pie charts, histograms, line graphs for example
- Scale – marks on a visualization that indicate the range of data values presented. A scale on a graph reflects the magnitude of the data presented.

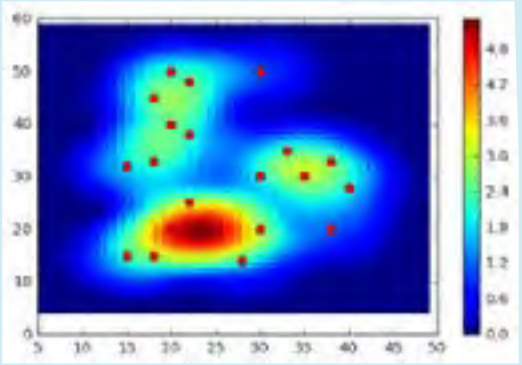
Common Types of Data Visualization

- A pie chart uses “pie slices” to show relative sizes of data.
- A histogram uses bars of different heights to group data into range.
- A scatter plot uses points plotted on an XY axis to show the relationship between two sets of data.

How will a technician use data visualization?

Evan Garcia is a technician for Green Mountain Power Company. He is responsible for tracking increased system outages over time across a metropolitan network, collects outage statistics, including system logs, environmental information, and helpdesk ticket details from network nodes and service centers in order to determine the cause. Evan stores the data in an Excel workbook, then imports data into SAS, Tableau, or MS Power BI visualization tools and creates a dashboard to present to management. The data dashboard provides an interactive geographical heat map showing outage details and other graphical representations of his data analysis of the event. The heat map allows management to make real-time decisions and troubleshoot problems.

*A **heat map** uses a warm-to-cool color spectrum to represent data values by color.*







Skills Needed for a High-Pay Rewarding Career

- Describing the different ways to visualize data and data visualization tools.
- Cleaning and manipulating raw data and prepare the data for analysis.
- Analyzing various types of datasets.
- Analyzing real-world problems based on data visualization techniques and produce reports.
- Designing and developing data dashboards.

Education

Your local community college provides the advanced technology classes you will need. Skills for analyzing and visualizing data are most often taught within Data Analytics programs offering associate degrees and one-year certificates. Data visualization skills are also important in other areas of technical fields such as agricultural, cybersecurity, biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats.

Find your nearest community college here.

Future Trends

The Future of Data Visualization explains that as the amount of data grows, "people will have higher expectations for data availability, its accuracy, usefulness and how it's visualized in future. The trend is clearly for new tools to provide more data to its users, not less."

- Increased amount of available data
- Greater data accuracy
- Better data processing and visualization design tools
- Increased cloud connectivity for data storage and access
- Immersive, interactive data visualization
- Virtually assisted field service

Learn More

- What is Data Visualization?
- Fundamentals of Data Visualization

For additional tools and information visit preparing technicians.org





Data Visualization

What is Data Visualization?

Data visualization is the graphical representation of information and data. By using visual elements like charts, graphs, and maps, data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data.

Data Visualization Beginner's Guide

Data Visualization Technician Competencies

- Describe the different ways to visualize data
- Select appropriate data visualization tool
- Clean and manipulate raw data
- Analyze various types of datasets
- Analyze real-world problems based on data visualization techniques
- Design data dashboards

Cross-disciplinary Skills

- Using basic statistics
- Collecting and representing data
- Creating reports
- Communicating complex information
- Collaborating with others
- Using essential office software

IT Scenario

A large office building noticed that network performance varied dramatically for different users throughout the building. This led to complaints and less efficiency from employees. The onsite technician, Ben, has been troubleshooting router performance, as well as reaching out to the office's ISP to confirm delivery of the purchased network speeds. He has improved some individual devices' performance with basic PC cleanup, but has been unable to find a consistent solution. Ben decided to create a visualization of the LAN. Using Microsoft Excel, he creates a spreadsheet to store device information and performance data he has collected over the last several weeks. He creates several charts using this data, plotting response times against physical distance in one chart and against connection type in another. By using this method of visualization, he can clearly spot patterns in the lower and higher-performing devices. Benjamin installs several wireless access points in areas of the office with a weaker connection and adds ethernet connections to many of the stationary devices in executive offices andconference rooms, such as desktop PCs and printers. The users find their internet speeds have improved the office now able to make full use of their internet service with fewer disruptions resulting in increased efficiency and productivity.

READ MORE ▸

The Future of Data Visualization, Towards Data Science
How Data Analytics and Visualization Drives Operational Efficiency, IndustryWeek
Manufacturing Dashboards: Why Visualizing Data Is Important for Manufacturers
Articles on how visualization is used, Towards Data Science
Using Big Data in Manufacturing to Drive Value in 2020 and Beyond, Informatica

Data Visualization

Activity

This activity is designed to help students think about the data generated by equipment and processes in their field of study and how that data is interpreted and communicated. Depending on the level of your students, your options are to have students generate their own data; provide simple data in a spreadsheet; or select a more complex dataset from the sites listed below. Tableau, a common data visualization software, provides free access for students and instructors but you could use MS Office tools (e.g. Excel, Word) instead. Students will review a dataset, determine what the data trends mean, and create a graphic communicating the correct interpretation of the data.

Free Public Datasets

- Free public datasets for your science project
- Global open data at national, regional, and city levels: links to public databases

Tools for Data Visualization

- Excel Easy
- Get started with Power BI Desktop
- Tableau instructional videos
- Tableau Desktop is free for students and instructors at accredited academic institutions.

  Request a student license.

  Request an instructor license.

Warm-up

Students need to be able to select the appropriate type of graphical representation to communicate data effectively to prevent misunderstanding. Begin by reviewing the concepts in "Use and Misuse of Graphical Representations," with students.

Then follow up with questions in the context of students' field of study:

- What equipment and processes are we operating that generates data?
- When we monitor data from our equipment and processes, what are we trying to discover?
- How would you visualize that data to communicate its meaning to someone unfamiliar with your field?

Activity Steps

1. Acquire your dataset.
2. Organize and clean the data
3. Determine what data you need for the visualization.
4. Import your data into a visualization tool.
5. Identify any trends in the data, if any.
6. Create a visualization of the data.
7. Display and explain it to others.

ABOUT THE PROJECT

Preparing Technicians for the Future of Work, a project of the National Science Foundation Advanced Technological Education program, recognizes that technicians graduating today need an expanded skill set to remain competitive in the global economy. The project focuses on three skill areas: data knowledge and analysis, advanced digital literacy, and business knowledge and processes. Learn more at preparingtechnicians.org.

(Back)

DATA LITERACY/FLUENCY

What is data literacy/fluency and how is it related to Data Knowledge & Analysis?

Data literacy/fluency is the ability to understand, analyze and draw insights from data and communicate about it clearly. Technicians use data to solve problems and improve operations. In troubleshooting a piece of equipment, for example, a technician gathers and analyzes data to diagnose the problem, and based on that data, identifies and applies a solution, and then uses data to verify the problem has been resolved.

Vocabulary

- **Data management** – the practice of collecting, keeping, and using data securely, efficiently, and cost-effectively
- **Spreadsheet** – a tool which stores data in a grid of rows and columns
- **Data backup and recovery** – the process of backing up data in the case of loss and setting up systems that allow data to be recovered due to data loss
- **Statistics** – mathematics used to predict outcomes by examining numerical data relationships
- **Analytical tools** – tools, such as Excel, R, and SAS, that enhance and automate data analysis
- **Data modeling** – the process for creating diagrams to represent data stored in a database
- **Data visualization** – software that represents information in the form of a chart, diagram, or picture

How will technicians use data literacy/fluency?

Many towns or cities are served by municipal water treatment companies and have Water and Wastewater Treatment Technicians on staff who use data to ensure drinking water is safe and clean. Trinh is a Water Treatment Technician at her town's municipal water and wastewater treatment facility. One of her responsibilities is testing water samples for acid and pH levels, bacteria, and a variety of contaminants. Trinh uses equipment such as a Dual Input Analyzer, Nitrate Analyzer and Free Chlorine Sensor to collect the data she needs. Trinh is part of her organization's Consumer Confidence Report team that prepares an annual report to distribute to the public as required by the Environmental Protection Agency (EPA). Trinh gathers the required data and explains it to the communications team who then writes the report to distribute to all their water customers.





DATA LITERACY/FLUENCY

Skills Needed for a High-Paying Career

- Locating and acquiring data relevant to a particular problem
- Organizing data in tables and spreadsheets
- Applying basic mathematics to clean up raw data
- Creating visualizations to communicate results

Education

Your local community college provides the advanced technology classes you will need. Data literacy and fluency skills are most often taught within Data Analytics or Data Science programs offering associate degrees and one-year certificates. You'll also find applicable skills in technical specializations, such as cybersecurity, biomedical, energy, and environmental technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats.

Find your nearest community college here.

Future Trends

Data, once a tightly held commodity that was costly and difficult to share, is now often very low cost or free. The generation of large amounts of data (Big Data) has increased substantially. This means a future where:

- Data is available autonomously using the Internet of Things (IoT)
- Artificial intelligence, machine and deep learning can predict future outcomes
- Sensors on objects send real-time data feeds

Learn More

- What are Data and Data Literacy? (video)
- Data Literacy for All (free eLearning program)
- The Language of Data (free course)

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DATA LITERACY/FLUENCY

What Is Data Literacy/Fluency?

Data literacy/fluency is the ability to understand, analyze and draw insights from data and communicate about it clearly. It is becoming increasingly more important as data becomes the new currency for business. Data literacy/fluency means being able to:

- **Read data**: understanding what data is and the aspects of the world it represents
- **Work with data**: including creating, acquiring, cleaning, and managing it
- **Analyze data**: filtering, sorting, aggregating, comparing, and performing other analytic operations on it
- **Persuade with data**: using data to support a larger narrative that is intended to communicate some message or story to a certain audience. (source)

Data Literacy/Fluency Competencies

- Locating and acquiring data relevant to a particular problem
- Organizing data in tables and spreadsheets
- Applying basic mathematics to clean up raw data
- Creating visualizations to communicate results

Cross-disciplinary Skills

- Using basic statistics
- Selecting and utilizing appropriate analytics tools
- Using data visualization software
- Communicating complex information

Bioinformatics Scenario

Ray is a Bioinformatics Technician at a cancer research center. He maintains the laboratory's electronic records and provides preliminary data analysis to assist the research scientists with their investigations of potential treatments. This week his center was asked to contribute data to a study on promising new research. Ray needs to determine which data is relevant to the research, extract it from the database, use sophisticated software to analyze it and then visualize it to present to his supervisor. Ray looks forward to reading the study once it comes out so he can see firsthand how his cancer research center's contributions are impacting the search for a cure.

Agriculture Scenario

Ann is a Food Science Technician who works for a large citrus grower. As part of her responsibilities, Ann collects and tests soil and water samples. While performing this function was essential, it was time consuming and only yielded basic data about the soil and trees. Ann recently assisted her company with adopting soil sensors. These are devices that are inserted in the ground at various locations in the grove where they provide highly specific data, such as moisture levels, fertilizer effectiveness, and plant reaction to variable conditions, including temperature and light. The sensor measurements deliver real-time data to a computer station Ann has set up in her office. She is then able to provide this data quickly to the grove manager, allowing the company to act when a field condition, such as low water levels, produces a stress reaction, can be mitigated.

DATA LITERACY/FLUENCY

Activity

This activity is designed to help students think about how data is used to solve problems and make decisions. Students will consider the way climate data influences the work of two industries: agriculture and energy and utilities.

Warm-Up

Review the definition of data literacy/fluency. Ask students:

- How is data collected and used in your career field?
- What STEM technician careers use data about the climate as part of their everyday work?
- What type of data do they need?
- How do they use this data?

Activity Steps

1. Go to https://www.climate.gov/maps-data/climate-data-primer.
2. Read the overview "Why does climate data manner?"
3. Go to the National Center for Environmental Information, https://www.ncei.noaa.gov/about/our-impact, and select either Agriculture or Energy and Utilities. Read the document and be prepared to share with the class what you learned about climate data and the impact of climate on that industry.
4. Share in small groups or with the class what you learned.
5. If there's time, explore the case studies within Value of Data and Tools and Resources sections at the bottom of Our Impact.

Tools Available

- How to Use Google Sheets (video)
- Videos and handouts for Excel Data Analysis Basics taught by Mike Girvin at Highline College
- Data Literacy for All (free eLearning program)

Read More

- What is Data Literacy?
- Data Literacy Project
- Developing a Data-Literate Workforce

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SPREADSHEETS

What are spreadsheets and how are they related to Data Knowledge & Analysis?

A spreadsheet is a file created using software such as Microsoft Excel to capture, display, and manipulate data arranged in rows and columns. Technicians collect data as part of their normal daily workflow to install and configure systems, diagnose problems, and perform maintenance. Spreadsheets are a convenient and simple tool with which to store this data. Once the data is stored, the technician can use spreadsheet features to analyze data, including summaries, trends, and patterns. Spreadsheets can also be used to create data visualizations.

Vocabulary

- **CSV** – the file extension indicating that data will be displayed separated by commas and line breaks; compatible with all spreadsheets
- **Data visualization** – represents information in the form of a chart, diagram, or infographic so that data can be quickly and easily understood
- **Export** – to copy or move data from one program or computer to be saved or imported into another program; exporting can be used to back up and save important data or to move data between versions of a file
- **Pivot table –** a Excel tool used to reorganize and summarize data from specific rows and columns of data, making it easier to spot trends and patterns
- **TSV** – the file extension indicating data will be displayed separated by tabs; used when data is stored in tables
- **XLS or XLSX** – the file extension that indicates a spreadsheet can be opened in Microsoft Excel

How will technicians use spreadsheets?

Shanice is a Solar Technician on a solar farm. Recently her company installed sensors on each panel. The sensors collect data including voltage, current, temperature and the amount of sunlight reaching the panel. When there was a problem with the system in the past, Shanice would need to walk through the solar farm and examine each panel to determine which panels were malfunctioning. Now the sensors on the panels transmit readings to a database available on a computer at her workstation. When there is a system problem, Shanice logs into the database, exports the data to a CSV file, or a comma separated file, clicks on “Save As,” and selects the “xlsx file” option where it’s converted to an Excel spreadsheet. She then can review data that is displayed in with rows and columns (or use the program to create data visualizations) where she can easily spot the specific panel that is the source of the issue. Shanice can go directly to that panel and service it.





SPREADSHEETS

Skills Needed for a High-Paying Career

- Creating spreadsheets
- Manipulating data cells using copy/cut/paste
- Analyzing data
- Organizing and formatting related data
- Sorting data
- Creating charts
- Importing data from an external source

Education

Your local community college provides the advanced technology classes you will need. STEM technicians often use spreadsheet programs that are unique to their field. Spreadsheet skills are most often taught within Information Technology, Computer Science, Data Science, Data Analytics, or Business programs offering associate degrees and one-year certificates. You'll also find applicable skills in technical specializations, such as agriculture, cybersecurity, biomedical, energy, engineering, and environmental technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. **Find your nearest community college here.**

Future Trends

In the future, spreadsheets will be able to:

- Work seamlessly with Big Data
- Analyze and correct unreliable and missing data
- Join external datasets together
- Provide analysis tools which utilize machine learning

Learn More

- What is a Spreadsheet?
- Microsoft Excel Video Training
- Google Sheets Tutorial
- Creating Pivot Tables in Excel

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SPREADSHEETS

What are spreadsheets?

A spreadsheet program stores data in a grid of rows and columns and a file in the program may contain multiple worksheets used for organization, analysis, and storage of data in tabular form. Data may consist of numbers, formulas, or text. Spreadsheets have features that enable users to store, analyze, model and visualize data. Common spreadsheets include Microsoft Excel and Google Sheets.

Spreadsheet Competencies

- Creating spreadsheets
- Performing basic functions, including sums and averages
- Manipulating data cells
- Analyzing data
- Organizing and formatting related data
- Sorting data
- Creating charts
- Importing data from an external source

Cross-disciplinary Skills

- Applying computational thinking
- Using basic statistics
- Utilizing analytics tools, such as Excel
- Managing data
- Demonstrating data literacy
- Creating data visualizations
- Communicating the implications of the data

Advanced Manufacturing Scenario

Mohammed is a Manufacturing Technician for a plastics manufacturing company where he works with an injection molding machine. Mohammed uses an HMI, a touch screen with that allows him to control the machine and track various functions, such as the temperature of the molds and the operation of the hoses. Since maintaining machinery is part of his responsibilities, Mohammed needs to periodically collect data that provides insight into the machine's functioning over time to determine when to do preventive maintenance. When Mohammed's company installed the HMI for his machine, they were able to set up a reporting feature where he can download the data directly into an Excel format. He views the data in rows and columns by date and function and uses that information to determine whether maintenance will be needed to ensure his machine is functioning properly.

Engineering Technologies Scenario

Lisa is a Materials Technician in a plasma lab where they are studying how to the shrink the size of chips used in electronics. She is responsible for setting up test fixtures, conducting materials and component tests, and collecting data. Lisa needs to share data on her materials testing with her supervisor weekly. She finds charts the most effective way to visually summarize the data. To accomplish this, she tracks and stores data daily exported to an Excel spreadsheet. On Fridays, Lisa creates charts by highlighting the data she wants to share, clicking on "Insert-Recommended Chart" and then selecting Bar or Pie charts. She then emails them to her supervisor or prints them out before discussing the week's testing results.

SPREADSHEETS

Activity

This activity is designed to give students hands-on experience with creating a simple spreadsheet that a technician might use in real life. It can be done in pairs in a classroom or by individual students via distance learning.

Warm-Up

Remind students that technicians collect data as part of their daily workflow to record, organize, and store data. Technicians then can use spreadsheet statistical tools and application features, such as Excel's Power Query or pivot tables (not introduced in this activity), to analyze, combine, and refine the data. Ask students:

- Who has created and/or used Excel spreadsheets?
- What did you use the spreadsheets for?

Activity Steps

1. Have students get into pairs. Each pair needs at least one computer with Excel. If they do not have Excel loaded, students can sign up for a free account at https://www.microsoft.com/en-us/microsoft-365/free-office-online-for-the-web.
2. Pairs are going to watch the video Calculating Wind Power in Excel and create the same spreadsheet as demonstrated in the video. They can stop the video or go back, as needed, so they are able replicate all the steps.
3. The pairs will need to have some basic cells ready in the spreadsheet as shown in the video.
   a. Click on "new spreadsheet."
   b. Type "Wind Velocity (meters and seconds)" in the first cell.
   c. In column A, type the numbers 1-11 in each cell going downwards.
   d. In column B, type "Wind Power (watts/meter^2)."
4. The pairs follow the steps in the video to add the data.
5. Ask students what they learned from the activity about how spreadsheets function.

Tools Available

- Excel is a common spreadsheet program. Users with a school email can set up a free account.
- Google Sheets offers similar tools and is free to those who have a Google log-in.
- On an iPad, Numbers is the free spreadsheet app.

Read More

- Twelve Best Spreadsheets to Try
- Is the Age of the Spreadsheet Over?

ABOUT THE PROJECT

Preparing Technicians for the Future of Work, funded by the National Science Foundation Advanced Technological Education program, recognizes that technicians need an expanded skill set to remain competitive. The project's Framework for a Cross-Disciplinary STEM Core outlines recommendations for incorporating knowledge and skills in Advanced Digital Literacy, Data Knowledge and Analysis, and Business Knowledge and Processes. Learn more about implementing the Framework at preparingtechnicians.org.

ANALYTICS TOOLS

What are analytics tools and how are they related to Data Knowledge and Analysis?

The practice of analytics uses insights gained from data analysis to identify and anticipate trends and outcomes for making smarter, data-driven business decisions. Analytics software tools are available to make this more efficient by reducing manual computational tasks for gathering and analyzing the data.

Vocabulary

- **Business analytics (BA)** – focuses on predictive and prescriptive analysis of data
- **Business intelligence (BI)** – focuses on descriptive and diagnostic analytics
- **Descriptive analytics** – uses data to understand what has happened in the past
- **Diagnostic analytics** – uses data to understand what is happening now
- **Predictive analytics** – uses data to predict what could happen in the future
- **Prescriptive analytics** – uses data to support recommendations for actions that should be taken to improve future outcomes

How will technicians use analytics tools?

Lisa is a building technician for a commercial property management company in a fast-growing metropolitan area with many new office buildings. These new buildings typically are installing what is called a DDC or direct digital control systems. A DDC controls one or more building systems, including HVAC (heating, ventilation, and air conditioning), fire alarms, and security systems using sensors that transmit data to a remote computer workstation with specialized software where a technician can monitor the system. Lisa recently needed to troubleshoot an HVAC problem when one of the tenants complained it was chilly in their office in the morning. Lisa used data from the DDC to determine the temperature on their floor over the past several weeks. The data showed the HVAC system was adjusting to 65 degrees at 6:00 pm and was re-adjusting to 72 degrees at 8:00 am. Lisa also examined security data from the DDC and noticed that three employees had begun arriving earlier to work than in the past, at 7:30 am rather than 8:30 am when the rest of the employees arrived. This meant the temperature in the office was seven degrees cooler than the 72 degrees for which it was set for during the company's office hours of 8:30-5:00. Lisa shared this insight with the office manager. The office manager stated they recently hired three new employees to work an earlier shift. Lisa adjusted the DDC from her workstation to go back to 72 degrees at 7:00 am to ensure the office was more comfortable for all the employees. In this case, Lisa used a combination of descriptive and diagnostic analytics to solve the problem.





ANALYTICS TOOLS

Skills Needed for a High-Paying Career

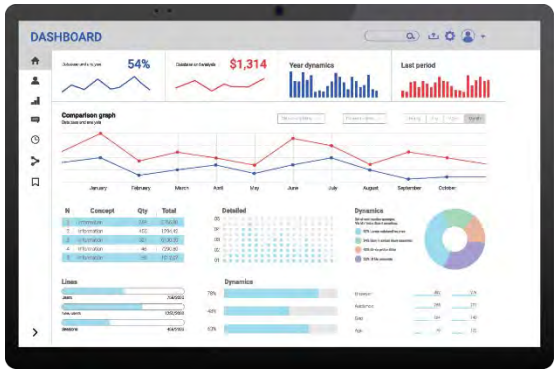
- Comparing and selecting appropriate analytics tools
- Writing basic R and Python scripts to import and summarize data
- Interpreting statistics
- Using tools like Excel, PowerBI, or Tableau to import and analyze data
- Creating data visualizations, reports, and dashboards
- Translating data analytics into actionable business recommendations

Education

Your local community college provides the advanced technology classes you will need. The number of associate degree programs in Data Analytics is growing but the required skills are often taught within Data Science or Computer Information Science programs. Many colleges offer short courses as well. You'll find applicable skills in technical specializations, such as cybersecurity, biotech, advanced manufacturing, and energy technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of analytics tools will include:



- A focus on data quality management
- An increase in predictive and prescriptive analytics capabilities
- Hyperconnected tools sharing data more widely via the Internet of Things (IoT) and cloud technology
- Increased automation of analytical processes
- Artificial intelligence (AI) equipped tools

Learn More

- What is Business Analytics? Using Data to Predict Business Outcomes
- What is Manufacturing Analytics?

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ANALYTICS TOOLS

What are analytics tools?

Analytics software takes "big data" and uses Artificial Intelligence (AI), statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions.

Analytics Competencies

- Comparing and selecting appropriate analytics tools
- Writing Basic R and Python scripts to import and summarize data
- Using tools like Excel, PowerBI, or Tableau to import and analyze data
- Creating data visualizations, reports, and dashboards
- Translating data processed using analytics tools into actionable business recommendations

Cross-disciplinary Skills

- Basic programming
- Using spreadsheets
- Interpreting statistics
- Selecting and using analytics tools
- Communicating effectively with internal and external stakeholders

Agriculture Scenario

Dan is a Fisheries Technician on a salmon farm. He was researching ways the farm could economize feeding their fish and found a company that had advanced aquatic technologies that can collect and analyze feeding behavior data using sensors, underwater cameras, and data analytics software. His supervisor agreed that having those tools could provide them with greater insight into the feeding patterns, resulting in raising healthier fish, saving money, and increasing the farm's efficiency. Dan worked closely with the aquaculture technologies company to set up the system to evaluate feeding behavior of the fish based on water temperature and dissolved oxygen, to find out when the fish were reaching satiation, and to determine the quantity of pellets left uneaten and falling to the bottom of the pens. The analytics software saved all the data and uploaded it to a secure private cloud. Dan was able to obtain descriptive and diagnostic analytics data and provide information to the company to help them optimize their fish feeding strategies.

Information Technology Scenario

Cameron is a Network Technician for a locally owned group of five automotive repair shops that specialize in hybrid vehicles. They have a client/server network configuration enabling all the shops to share a common customer database, maintenance records, accounting system, and office software package. Over the past two weeks, the server went down several times and Cameron needed to get to the bottom of what was causing the outages and take action to resolve the problem. Cameron used network monitoring agents and software to gather and analyze network data. Agents are small pieces of equipment located at each shop that monitor the network at that location. Monitoring software takes that information, runs metrics, and reports issues, with details about what the issue is and what caused it. Cameron was able to determine that the outages stemmed from bandwidth overload at one of the shops where they were receiving a large number of repair records transferred electronically from another shop. While both shops completed their end of the file transfer process, Cameron didn't expect the issue to continue but he communicated to the shop managers that they should consider using the cloud in the future as the business continues to grow.

ANALYTICS TOOLS

Activity

This activity is designed to help students use analytics tools by exploring an open-source Tableau dashboard from a manufacturing company. Begin by reviewing the terminology from the student card. Next, the students will get into small groups and explore the Tableau dashboard. Then they will work in groups to explore the descriptive and diagnostic analytics of production stops using data from the dashboard.

Warm-Up

Review the vocabulary and concepts provided on the student card. Ask students to share any stories they have from school, work, or home where analytics tools were used, though they may not have necessarily called it by its formal name.

Activity Steps

1. Ask the student to think about how the four types of analytics can be used to make decisions regarding pieces of equipment, such as timing of repairs or if a machine needs to be replaced.
2. Have students go to this public Tableau workspace on Manufacturing Analytics where they will find an open source data analytics dashboard from a manufacturing facility. This dashboard provided data visualization regarding times the machines are not working.
3. Break students into small groups to explore the interactive dashboard together.
4. Next, in their groups, have them identify:
   - Descriptive analytics – What has happened?
   - Diagnostic analytics – Why is it happening?
5. Then, have the groups work together to hypothesize:
   - Predictive analytics – What could happen?
   - Prescriptive analytics – What should happen?
6. Each group presents their findings to the class.

Tools Available

- Excel, Power BI, and Tableau are common tools used for analytics.
- Basic Python and R are open-source programming languages for analytics. Python Vs. R: What's the Difference?
- A variety of proprietary tools are available in the market.
  Top 10 Business Analytics Tools Used by Companies Today

Read More

- Business Analytics: What It Is and Why It's Important

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Preparing Technicians for the Future of Work, funded by the National Science Foundation Advanced Technological Education program, recognizes that technicians need an expanded skill set to remain competitive. The project's Framework for a Cross-Disciplinary STEM Core outlines recommendations for incorporating knowledge and skills in Advanced Digital Literacy, Data Knowledge and Analysis, and Business Knowledge and Processes. Learn more about implementing the Framework at preparingtechnicians.org.

Network Communications - Internet of Things (IoT)

What is the Internet of Things (IoT) and how is it related to network communications?

The Internet of things (IoT) consists of physical devices connected to the Internet. IoT devices are a combination of sensors, software, and electronics that connect to a central location usually in the cloud. They are often connected through a wireless network through which they communicate with one another and feed information to a user's mobile device or computer. Through the device, the user can monitor a condition or control a process through a control panel or dashboard, known as the Human-Machine Interface. Internet-connected doorbells, thermostats, speaker systems and wearable fitness trackers are everyday examples of IoT devices. In industry, a variety of sensors monitoring quality and machine operational parameters for preventative maintenance.

Vocabulary

- Smart sensors – devices that receive and process data before sending to a centralized source; flow sensors used to measure water and natural gas usage – smart meters – are an example
- Cloud computing – delivery and storage of data over the Internet rather than on-site; Google's gmail is an example.
- Information security – processes used to protect information from unauthorized access, modification, or destruction. Requiring password entry to access devices and content is an example.

How will technicians use network communications and IoT technologies?

Network Communication Technicians familiar with IoT technologies will install, monitor, and maintain the IoT devices and the network communication software that connects them to ensure proper operation. This includes tasks such as installing software updates, developing procedures to detect and prevent system hacking, testing the network for malware, and troubleshooting system malfunctions. Their job often requires creative problem-solving, as in this example:

A company that manages large parking garages wanted to reduce the time its customers spent searching for open parking spots. Some drivers spend several minutes traveling up and down multiple floors to find an open parking spot. The distracted drivers looking for open parking spots are also a hazard to other cars and pedestrians. A network technician is assigned to investigate a solution. After reviewing several options, the network technician decided to implement an IoT solution that includes sensors, signs, and a mobile app. IoT sensors were installed to monitor the status of each parking spot. The status of each parking spot was sent to a centralized computer. If a spot were available, signs throughout the garage would provide directions to the exact location on the garage floor to the open parking spot. The status of each parking spot was also available on a mobile app to let people know before entering the garage how many spots were available and on what floors. This IoT solution reduced customer wait times, increased safety, and increased parking garage profits.





Network Communications - Internet of Things (IoT)

Skills Needed for a High-Paying, Rewarding Career

- Advanced computer programming
- Connecting sensors to networks
- Identifying program errors
- Troubleshooting complicated computer networks
- Interpreting detailed schematic diagrams
- Maintaining complex IoT networks
- Configuring and Testing new software instillations
- Maintaining and repairing hardware and peripheral devices
- Developing robust cyber security interfaces

Education

Your local community college provides the advanced technology classes you will need. Skills for building and maintaining network communications networks within the Internet of Things are most often taught within Engineering Technology, Information Technology, or Computer Information Systems programs offering associate degrees and one-year certificates. You will also find the skills applicable in technical specializations, such as cybersecurity, biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

Current and Future Career Opportunities include working with:

- "Smart home" technologies
- Complex sensors
- Sophisticated user infrastructures
- Industry and government cyber security
- Dynamic mesh computer interface architecture
- Artificial Intelligence applications
- Data brokering
- Informatics
- Robot/human inter-communications

Learn More

The Internet of Things tutorial (includes Career Opportunities)

Free online course: Introduction to the Internet of Things

ABOUT THE PROJECT:
Preparing Technicians for the Future of Work, a project of the National Science Foundation Advanced Technological Education program, recognizes that technicians graduating today need an expanded skill set to remain competitive in the global economy. The project focuses on three skill areas: data knowledge and analysis, advanced digital literacy, and business knowledge and processes. Learn more at preparingtechnicians.org.





Network Communications - Internet of Things (IoT)

What is the Internet of Things (IoT) and how is it related to network communications?

IoT devices are a combination of sensors, software, and electronics that connect to a central location usually in the cloud. They are often connected via a wireless network through which they communicate with one another and feed information to a user's mobile device or computer.

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects (e.g. car with lane sensors), animals (e.g. livestock with biochip transponders) or people (e.g. heart rate monitors) that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. "Internet of Things (IoT)," TechTarget IoT

Network communication defines a set of protocols (rules and standards) that allow application programs to talk with each other without regard to the hardware and operating systems where they are run. "Basics of Network Communication," IBM Knowledge Center

Scenario 1
Manufacturing Technologies

A manufacturing facility had problems with consistent equipment breakdowns causing the assembly lines to stop working. The equipment was overheating, vibrating, and losing electrical connectivity. The maintenance technicians would find the problems but only after the assembly line broke down. The company was losing money on a weekly basis. The plant manager asked Cynthia, a production technician, to find a solution. After a few days Cynthia reported to her manager she found a solution using IoT. Cynthia's plan was to install IoT devices to monitor the part of the assembly line that was breaking down. The IoT devices were attached to the motors, conveyor belts and electrical systems. and then connected to a central monitoring system. The central monitoring system allowed the maintenance technician to identify and repair parts that were going bad before they failed and shut down the assembly line.

Scenario 2
Energy and Environmental Technologies

IoT is helping people save energy and make money savings decisions about their power usage. Smart meters that attach to buildings and connect to a smart energy grid have become the top IoT device among utility companies. Data from IoT energy smart meters can be sent to a mobile app to monitor how much power has been consumed. It allows people to know exactly how much they are spending so they only use what they can afford. Consumers can use IoT devices attached to appliances to turn off the power to appliances to reduce electrical waste and save money.

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Read More

- "IoT and Biotechnology: A Promising Technology Fusion for Sustainable Development," *Biotech Express Magazine*
- "The Relation between IIOT, SCADA, and HMI Explained," *Schneider Electric Blog*
- "Case Studies in Agtech Smart Farming"

Network Communications - Internet of Things (IoT)

IoT Technician Competencies

- Designing and installing well-functioning computer networks, connections, and cabling
- Troubleshooting system failures and identifying bottlenecks to ensure network efficiency
- Testing and configuring software
- Maintaining and repairing hardware and peripheral devices

Cross-disciplinary IoT Skills

- Using sensors to collect information
- Transferring information to and from the cloud
- Analyzing information provided by internet-connected devices
- Storing information safely
- Applying appropriate digital communication protocols

Read More

IoT Case Studies: Companies Leading the Connected Economy

Workforce Domain Curriculum and Faculty Development Resources for IoT

Activity

This activity is designed to help students think about connected equipment and processes in their field of study. Begin with the guiding questions in the warm up. Students will identify connected devices and the tasks they automate, relative to their field, and illustrate the connections.

Warm-Up

- What equipment are we operating remotely?
- What processes are we monitoring?
- What types of equipment and devices need to communicate with each other?
- What are the critical parameters in which we are working?

Activity Steps

1. List three tasks from your field of study that have been automated
2. Describe how a technician monitors the process for safety, efficiency, and accuracy
3. Identify the central data hub (i.e., cloud, physical server, other)
4. Sketch a diagram showing the network of connected devices
5. Explain why the specific devices are connected.





AUTOMATION, ROBOTICS, AND HMI

What Are Automation, Robotics, and HMI?

Automation and robotics are the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies are used to develop machines that can substitute for humans and replicate human actions.

A Human-Machine Interface (HMI) is a panel that that allows a human to control a machine. On modern machines, the interface is often a touch screen like an iPad. The HMI found in industrial environments is software that controls hardware and allows an operator to control machines.

Vocabulary

- **Collaborative robot (cobot)** — robots that can safely work near humans and are intended for direct human-robot interaction
- **Input/Output** — HMI devices or software applications that allow technicians to program and control robots
- **Mechatronics** — a field of study integrating electronics, mechanics, pneumatics, hydraulics and computer controls
- **Pick and place** — a repetitive part transfer task composed of a picking action followed by a placing action
- **Teach pendant** — a hand-held input device with which a robot can be programmed or moved

Automation, Robotics, and HMI

Technicians working with automated systems will use a combination of mechatronics skills such as computer programming and electromechanical knowledge.

Tammy works for a small manufacturing company that designs and creates customized metal parts for the shipping industry. The metal parts are cut and bent from a large piece of steel on a human operated machine then welded by hand. The owner asked Tammy to find out whether a robotic system would make the work safer, faster, and more precise. She met with several companies to discuss the options and cost of implementing robotics on the manufacturing floor. After months of research, the company purchased eight robots to automate the cutting, bending, and welding. Tammy and the technicians that had been doing the work manually were sent to robotics training so they could configure and code the robots using a coding language called Python. After several months of training, the robots were installed, and Tammy was made Production Lead to ensure they were successful. The staff appreciated that the company trained them to maintain the robots and did not eliminate their positions. After the robots were in place for about six months, the company realized a huge cost savings due to the increase in the number of parts that could be assembled during a shift and a significant reduction in parts that did not meet the quality checks.





AUTOMATION, ROBOTICS, AND HMI

Skills Needed for a High-Paying Job

- Applying general mechanical knowledge
- Troubleshooting automation systems
- Interpreting data read-outs from HMIs
- Installing, maintaining, and repairing hardware and peripheral devices
- Programming industrial robots and cobots

Education

Your local community college provides the advanced technology classes you will need. Skills for building and maintaining robotic systems within Automation, Robotics, HMI are most often taught within Mechanical and Robotics Engineering, Information Technology, or Computer Information Systems programs offering associate degrees and one-year certificates. You will also find the skills applicable in technical specializations, such as biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats.

Find your nearest community college here or search for robotics programs here.

Future Trends

As the adoption of Industrial Internet of Things (IIoT) Industry 4.0 technologies grows, automated systems and their infrastructure will become more sophisticated. Current and future career opportunities include working with:

- Complex sensors that collect more data
- Informatics to translate data into knowledge
- Industry and government cybersecurity
- Dynamic mesh computer interface architecture
- Artificial Intelligence applications
- HMI graphics creation
- Collaborative robots

Learn More

- Here Come the Cobots!
- Robotics Skills, Robotics Careers
- Automation: A Positive Force in the Power Sector
- Understanding the What and Why of HMI

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AUTOMATION, ROBOTICS, AND HMI

What Are Automation, Robotics, and HMI?

An industrial robot is machine controlled by an internal or external computer that can carry out a complex series of movements automatically. Robotic process automation (RPA) is the use of software with artificial intelligence (AI) and machine learning capabilities to handle high-volume, repeatable tasks that previously required humans to perform. (source)

A Human Machine Interface (HMI) is a software application that presents information to an operator about the state of a process and accepts and implements the operator's control instructions. Typically, information is displayed in a graphic format. (source)

Technician Competencies

- Installing and programming automation or robotic systems equipment and HMI software
- Troubleshooting automated production or robotics systems
- Determining causes of operational problems or failure
- Disassembling and reassembling robots or peripheral equipment to make repairs
- Maintaining service and operational records

Cross-disciplinary Skills

- Installing sensors to collect information
- Programming for updating and modifying equipment
- Analyzing information and diagnostics provided by internet-connected devices
- Organizing and communicating information effectively
- Storing data securely

Energy Scenario

Stephanie is a Smart Meter Technician for her local power company. She is responsible for troubleshooting and repairing Smart Meter systems for local commercial and industrial customers. One of her customers, the management company for a 10-story office building, called Stephanie to come to check out their Smart Meter system since it was reporting an error message. Smart Meters enable two-way automated communication between the power company and the customer, the customer and energy suppliers, and are to regulate electricity usage. Smart Meters record energy near real-time with automated communication between the meter and the energy suppliers, allowing it to adjust throughout the day. This enables her customers with better clarity about their energy usage and help them make better business decisions. This is essential for commercial and industrial companies given the amount of energy it takes to run their companies. After troubleshooting the error message, Stephanie was able to fix the problem with the Smart Meter within an hour.

Supply Chain and Logistics Scenario

Oliver, an Agricultural Technician, works at a facility that stores animal feed in large silos needed. He was searching for a way to remotely monitor, analyze, and mix the animal feed since the existing method was manual and time intensive. Oliver had to climb into each silo and physically check the level of the animal feed. The company also provides customized animal feed mixes from multiple silos. Customizing the animal feed required several workers using conveyor belts and it was often mixed improperly. Oliver researched several options that provided a visual representation and remote control for each silo and the conveyor systems. The best option was to install sensors and controls at the industrial facility and attach them to an HMI that can be programmed to display the status of each silo. From one HMI panel a single person is now able monitor and control all the silos and conveyors.

AUTOMATION, ROBOTICS, AND HMI

Activity

This activity asks students to explore industries that are early adopters of robotics and automation and one that has potential for transformation—the construction industry. Begin with the guiding questions in the warm-up. Students will identify familiar HMIs and the tasks they automate, relative to their daily lives and their fields of interest.

Warm-Up

Review the definitions of Automation/Robotics/HMI and the scenarios from the industries they discussed in class.

- Ask students in groups of 3-4 to list the HMIs they encounter on a daily basis.
- What automated processes are the HMIs connected to?
- What graphics do the interfaces display?

Activity Steps

1. Ask students to identify tasks within their technical field of study that used to be performed manually and are now automated.
2. Have student read Top Five Industries That Will Be Transformed by Robotics and Automation. Divide the class into five groups and assign each group an industry. Have them discuss how robotics and automation are transforming the way these industries do business and the changing role of technicians.
3. Have students watch the video What If We Automated Construction?

Discussion questions for the whole group:

4. How do automation and robotics have the potential to transform the construction industry?
5. Why do you think certain industries have been slower to adopt these technologies vs. the ones we read about?
6. What are three technician tasks that have be made safer and more productive using automation and robotics?

Tools for Learning About Robotics

Learn to code basic robot actions on a simulated robot. Complete the interactive learning experience at RoboMind Academy. Hour of Code is recommended for beginners.

Read More

- Top 10 Industrial Automation Trends in 2021
- Understanding the What and Why of HMI
- How IoT and Robotics are Evolving Benefit to the Supply Chain

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BASIC PROGRAMMING: PYTHON

What is Python and how is it related to basic programming?

Basic programming tells a computer what to do using a language (code) it understands. One easy-to-learn programming language is Python. It uses open-source code that can run on a variety of computer systems. Technicians use Python for a variety of applications, including data analysis and visualization, automation, web and mobile app development, software testing and Machine Learning.

Vocabulary

- **Debugging** – the process of finding and removing programming errors
- **Object** – a group of related functions and variables combined into a unit
- **Object-oriented programming** – code written using objects that interact with one another
- **Python Enhancement Proposal (PEP 8)** – a style guide for writing Python code
- **Repository** – a digital archive where all of the files for a project or application are stored along with the history of all changes made to those files
- **Software library** – a digital collection of reusable code developed for specific purposes and shared with programmers
- **Statement** – single line of code written that expresses an action to be carried out
- **String** – a sequence of characters
- **Syntax** – set of rules on how statements can be arranged in order for the program to run
- **Web framework** – a collection of code which allows developers to write web applications more easily

How will technicians use Python for basic programming?

Jamal is Geospatial Information System (GIS) Technician for a civil engineering firm. He is a member of a project team that assists energy and utility clients with where to place power and sewer systems in new commercial developments. Jamal is responsible for the data management and analysis for the team. He had been using Excel but after conducting research on other available tools, he wanted to use Python since it is a more powerful than Excel and is easy to learn. Python has a library called Pandas that is specifically for data management and analysis. Jamal discussed this with the GIS Analyst on the team, who supported this approach. Jamal participated in a coding bootcamp and was able to successfully transition to using Python for his data responsibilities. He found it easy to understand and use and will be demonstrating how he uses Python with the GIS Technicians on other teams at the company.

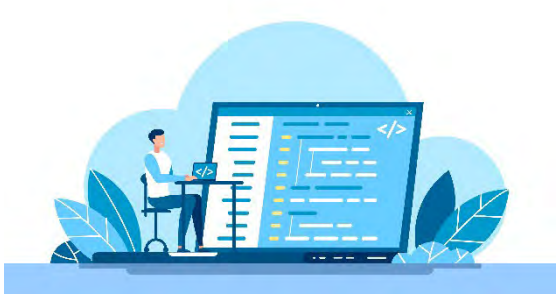




BASIC PROGRAMMING: PYTHON

Skills Needed for a High-Paying Career

- Applying the core concepts of basic programming
- Selecting the Python libraries that match desired outcomes
- Using Python for data analysis
- Thinking critically and asking questions



- Identifying and solving problems
- Communicating effectively with a variety of audiences

Education

Your local community college provides the advanced technology classes you will need. Skills for basic programming and Python are most often taught within Information Technology or Computer Information Systems programs offering associate degrees and one-year certificates. You will also find the skills applicable in technical specializations, such as advanced manufacturing, cybersecurity, biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of Python will include using it for:

- Artificial Intelligence (AI) and Machine Learning (MI) – With its libraries and frameworks, Python is helping to advance the science of emulating humans
- Cybersecurity – Python can perform a multitude of security tasks, protecting critical systems and information from digital attacks
- Automation – Python will continue to automate tasks traditionally performed by humans
- Data science – With its powerful capabilities, hundreds of libraries and frameworks, using Python for data science will continue to grow
- Blockchain development – Python can be used to create a digital public leger that records online transactions, keeping them secure

Learn More

- Code Academy's Learn How to Code: Basics of Programming
- What is Python Used For? A Beginner's Guide

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BASIC PROGRAMMING: PYTHON

What is Basic Programming in Python?

Basic programming is the set of instructions given to a computer to solve a problem or carry out tasks. This is done through a language it understands called code. Python is a an open-source high level programming language that is free to use for personal or commercial applications and can run on Mac, Windows, Lenox, and Unix systems. Python is beneficial tool for technicians since it is easy to learn and can be used for data analysis and visualization, automating tasks, app development and for writing Machine Learning algorithms.

Basic Programming: Python Competencies

- Applying the core concepts of basic programming
- Selecting the Python libraries that match desired outcomes
- Using Python for data analysis
- Thinking critically and asking questions
- Identifying and solving problems

Cross-disciplinary Skills

- Writing basic programming code
- Applying principles of Machine Learning
- Using statistics
- Analyzing and visualizing data
- Communicating effectively with a variety of audiences
- Continuously improving products, services, or processes

Supply Chain and Logistics Scenario

Don is a Logistics Technician at a temperature-controlled warehouse that stores and delivers food products to local social service agencies, hospitals, and school systems. He is responsible for the computer system used for scheduling, assigning, and routing multiple drivers to serve customers with unique priorities, service time windows, processing times, and geographical locations. Don tried using an off the shelf scheduling and routing system, but it was not providing the flexibility he needed. Don was able to develop a highly targeted software application using Python programming that addressed the unique needs of his company. Not only did this help optimize processes, but given that Python is free and open source, it saved his company money from having to use another off the shelf system.

Biotechnology Scenario

Amara is Biotechnology Technician at an oncology laboratory where they are researching cures for cancer. Amara is part of a team that is piloting bioprinting. Bioprinting is a special type of 3D printer that uses cells and natural or synthetic biomaterials to print layers of living tissue. This approach enables the company to test drugs without having to rely on organ donations or test on humans or animals. This is an emerging field and Amara is excited be part of the team. Given her daily experience with managing and analyzing data, she will be setting the printing parameters and speed, which will need to consider a wide number of variables. She will be using Python programming and researching how she might be able to utilize the PyBioMed library.

BASIC PROGRAMMING: PYTHON

Activity

This activity is designed to provide students the opportunity to explore options for learning Python programming. They will watch a video, read an article, discuss how technicians are using Python, and then select an option for learning Python programming if they choose.

Warm-Up

Review the definition and basic terms for Basic Programming – Python. Have students watch What is Python? Why is it so Popular? Ask the students if they have tried Python programming, and if so, to share their experiences. Discuss how technicians such as those depicted in the scenarios use Python and ask whether students have seen Python used in their fields of study.

Activity Steps

1. Explain that for learning a programming language, our learning styles vary. Some people prefer learning independently through tutorials or videos, whereas others may want to take a class online or in person. Students will have the opportunity to explore options and select one that would be the best match should they need or want to learn Python programming.
2. Have students read Top 13 Resources to Learn Python Programming all the way through.
3. Next, have students skim over the 13 resources and jot down 2-3 that align to their learning style and level of experience with Python programming.
4. For each of the 2-3 selections, student should go to the websites and explore what each approach has to offer.
5. Students select one that is the best match.
6. In groups of 3-4, have students share and explain their best approach for learning Python.

Tools Available

- Python Tutorial Topics
- Microsoft's Python for Beginners (free video series)
- Code Academy's Learn Python 3

Read More

- What Is Python Used For: 10+ Coding Uses for the Python Programming Language
- Why Learn Python? Six Reasons It's So Hot Right Now

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DIGITAL TWINS

What are digital twins and how are they related to Advanced Digital Literacy?

A digital twin uses a combination of technologies — industrial internet of things (IIoT) technologies, machine learning, sensors, and artificial intelligence— to create a virtual replica of a physical machine. It gathers and analyzes data to predict the impact of actions on that machine and its output. This means that a digital twin can run a simulation to answer questions about what might happen under specific conditions. For technicians, digital twins can improve efficiency and predict problems before they occur. (source)

Vocabulary

- **Artificial Intelligence (AI)** – the computer science involving software that imitates human decision-making, learning, and problem-solving processes
- **Internet of Things (IoT)** – a combination of digitally connected sensors, software, and electronics ("smart" devices) that connect to a central location and communicate with one another; humans often monitor and control using a dashboard on a computer or an app on a mobile device
- **Machine Learning** – the ability of a computer to analyze its own data, identify patterns, make predictions and decisions, and learn from the outcomes of those decisions without human assistance

How will technicians use digital twins in the workplace?

Ahmed is a Supply Chain Technician for a large warehouse that fulfills orders for replacement computer components. Ahmed's company had been receiving many complaints from customers about parts not arriving on time or receiving incorrect parts. He was searching for a more efficient way to identify potential problems before they impacted the customer. He had an inventory management system, but it was limited and did not take into account the bigger picture of the company's whole supply chain. He needed something that would not only provide an overview of the flow of parts to his warehouse but also predict production and transportation bottlenecks that might interfere with on-time delivery.

Ahmed researched a technology vendor that could partner with his company to build a digital twin connecting his inventory and operational data to a virtual model of the facility that would include data on the size, quantity, location, and demand for every item needing production, receiving, storage, and shipping. He was able to bring data from a variety of sources into one system where he could retrieve a complete view of suppliers, his inventory, and other details. The digital twin provided an in-depth view via real-time dashboards using advanced analytics fed to a cloud server. Ahmed was able to input process variables and the digital twin could run a virtual simulation and flag potential problems. This allows Ahmed to anticipate potential problems and adjust processes before the problems occur.

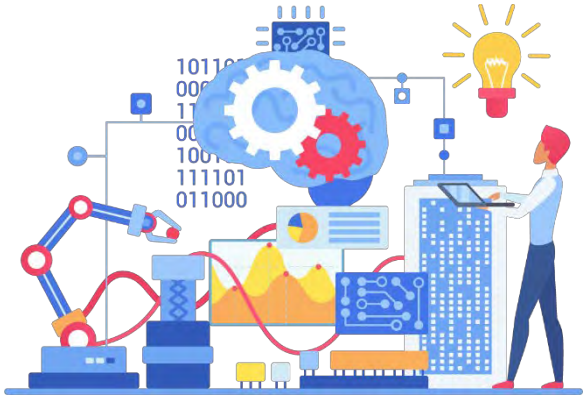




DIGITAL TWINS

Skills Needed for a High-Paying Career

- Troubleshooting wired and wireless networking protocols
- Implementing cybersecurity protocols
- Operating industry-specific technology
- Interpreting data generated through predictive analysis and adjusting processes appropriately
- Applying basic principles of artificial intelligence and machine learning



Education

Your local community college provides the advanced technology classes you will need. Digital twin technology requires a variety of skills which are taught within Electronics Engineering Technology, Computer Information Science, Data Analytics, or Advanced Manufacturing programs offering associate degrees and one-year certificates. Digital twins have applications in many technical fields such as cybersecurity, biomedical, energy, environmental, geospatial, logistics and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. **Find your nearest community college here.**

Future Trends

The adoption of digital twins by diverse industries is expected to grow exponentially over the next five years. The technology will continue to evolve with:

- Highly sophisticated and powerful simulations
- Continuous real-time monitoring
- Use of quantum computing
- Integration of systems and data across entire digital ecosystems

Learn More

- Digital Twins (podcast)
- What is a Digital Twin? How Does It Work? (video)

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DIGITAL TWINS

What are Digital Twins?

IBM explains that "a digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making." (source)

A digital twin models the functions of the real-world object or system. Sensors are attached to the physical product and monitor the numerous states of the system during its operation. Data is collected via telemetry and is transmitted to the digital twin where it will be analyzed in real-time. By using machine learning and artificial intelligence, the model can help in predictive analysis, data analytics, troubleshooting and performance.

Digital Twins Competencies

- Applying wired and wireless networking protocols
- Implementing cybersecurity protocols
- Operating industry-specific technology
- Interpreting data generated through predictive analysis and adjusting processes appropriately
- Applying basic principles of artificial intelligence and machine learning

Cross-disciplinary Skills

- Basic programming
- Using sensors to collect data
- Analyzing and visualizing data
- Applying continuous process improvement
- Communicating to internal and external stakeholders

Manufacturing Scenario

Roseline is a Manufacturing Technician for an original equipment manufacturer (OEM) that supplies sensors for an autonomous vehicle manufacturer. This is exciting work for Roseline and something she set out to do after she learned about self-driving cars from a Girls in STEM program in high school. After earning her AAS degree in advanced manufacturing, she secured a position as part of her company's ceramic sensor production team. The end user of her company's sensors has remained at the forefront of autonomous vehicle manufacturing through its use of digital twin technology. By utilizing digital twins, engineers at the vehicle manufacturer can simulate and validate each step of vehicle design, prototyping and development to identify problems and possible failures before producing real parts. Roseline was able to job shadow with the engineering team and found it fascinating to witness how the digital twin was used to test ceramic sensors against conditions such as minute changes in temperature or oxygen levels in real-time. With her associate degree, Roseline has the knowledge and skills to interpret data provided on the dashboard, but she plans to earn her bachelor's degree in engineering so she can continue to advance her skills in the autonomous vehicle manufacturing industry.

Renewable Energy Scenario

Daniel is a Wind Turbine Technician in Nebraska where he is part of team that is responsible for the maintenance and repair of the several hundred wind turbines on his company's wind farm. The company began using digital twin technology last year to predict how turbines function under specific weather conditions and how soon they would need repair. Each wind turbine has multiple sensors which feed data to condition-monitoring systems that then transmit real-time data to a digital twin. Technicians at the company monitor the digital twins and determine overall turbine health using that data and data from other sources that feed into the digital twin. In the past, Daniel would have to repair a turbine in the middle of the night, but since his company started utilizing digital twins, Daniel is able to do his work at scheduled times during the day. The digital twins predict problems before they occur, which enables Daniel's company to prevent significant turbine downtime, increase energy production maintain customer satisfaction.

DIGITAL TWINS

Activity

This activity is designed to help students think about the impact of digital twin technology across industries with significant transformation expected in the next few years. Students will watch a video that describes this transformation in the warm-up, explore use cases for a variety of industries, write their own use cases based on their individual career plans, and share the cases in pairs or small groups.

Warm-Up

Have students watch the video Why Digital Twins Will Be the Backbone of Industry in the Future. Then ask them to explain, in their own words, how digital twins will significantly transform nearly every industry in the future. Point out that trends are pointing to the "future" as being within the next 3-5 years.

Activity Steps

1. Glance over some of the use cases for digital twins technology: 15 Digital Twin Applications: Use Cases by Industry.
2. Select an industry related to your field of study. Be specific. For example, if you are studying to be a manufacturing technician, select the type of manufacturing (e.g., electronics, food products)
3. In 2-3 paragraphs, write your own "use case." Describe how digital twins might be used in your industry.
4. Think about how this impacts technician roles.
5. Share with a partner.

Tools Available

- Microsoft Azure Digital Twins Software (free trial)

Read More

- What is a Digital Twin?
- What is a Digital Twin and Why is it Important to IOT?
- Digital Twins: Bridging the Physical and the Digital

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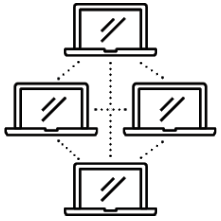
NETWORK ARCHITECTURE

What Is Network Architecture?

Network Architecture is the physical organization and logical design of software, hardware, protocols, and transmission media (wired or wireless). In a network, any connected device with an IP address is called a host. A host is called a client when it is requesting information, a server when it provides information, and a peer when it is able to both request and provide information.

The two most common types of network architectures are:

Peer-To-Peer networks consist of two or more computers linked to facilitate the sharing of information.



- All computers handle tasks and can communicate with each other.
- Small environments (10 or fewer computers)
- No dedicated server

Client/Server networks are configured so that clients access data from a server.

- Clients do not share data with one another directly.
- The server manages all the data, the network, and security.
- Clients communicate with server to request and receive permission to access data.

Vocabulary

- **Hub** – a device that has multiple ports for ethernet cables connecting devices and sending all of them incoming data
- **Logical network diagram** – graphic showing the flow of information through a network
- **Nodes** – connection points in a network (e.g., computers, printers, modems)
- **Protocol** – rules that govern how computers communicate with each other
- **Router** – a networking device connecting devices to each other and the internet
- **Transmission media** – the communication channel between computers

How will network architecture be used in the workplace?

Juan is an HVAC Technician who works with industrial customers who require troubleshooting, repair, and replacement of their HVAC systems. Juan is on the road servicing customers. After he completes his work at each site, he returns home to complete his work log using software installed on his work laptop. He has a router set up to provide high-speed Internet so that his computer can communicate with his company's server to relay this information. Juan's company uses a Client/Server Network so that HVAC technicians can complete their work logs remotely and the completed logs are available to his supervisor and others to view from the corporate office and/or remote locations. This is essential for record-keeping of company compliance with regulations. For example, when Juan replaces HVAC equipment and needs to dispose of the old equipment, the Environmental Protection Agency (EPA) requires a report from the company listing the amount and type of refrigerant disposed. The company's Health & Safety Manager has access to this information through the Client/Server Network and can complete the monthly EPA report.





NETWORK ARCHITECTURE

Skills Needed for a High-Paying Job

- Consulting on network design
- Configuring software on the hosts and infrastructure devices
- Maintaining and repairing host and infrastructure devices
- Preserving high levels of network security
- Troubleshooting network infrastructure problems
- Communicating network access and usage policies
- Staying informed about new network technologies

Education

Your local community college provides the advanced technology classes you will need. Skills for planning and designing communications networks are most often taught within Computer Information Systems programs offering associate degrees. Network architecture skills are also important in other technical fields such as cybersecurity, energy, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of network architecture includes:

- Cybersecurity mesh (security perimeter around a person or thing)
- Software-defined networking (SDN) and network functions virtualization (NFV)
- Use of networks as sensors to report and remediate system issues
- Autonomous networks that run, repair, and report without human interaction
- Edge computing (processing data closer to where it originates)
- Expansion of cloud platforms

Learn More

- Basic Networking Concepts-Beginners Guide
- Computer Network Architecture

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NETWORK ARCHITECTURE

What Is Network Architecture?

A network links two or more host devices to facilitate the sharing of information. These networks can be self-contained Local Area Networks (LANs) which are typically in the same building or Wide Area Networks (WANs) which allow organizations to communicate globally. Network Architecture is the design, implementation, and management of four elements that comprise a network.

1. Something to share — the **Services**
   - Documents, databases, media content, messaging, collaboration (using tools such as Zoom)
2. Physical pathways through which the services can be shared — the **Infrastructure**
   - Physical media (twisted pair cable, coaxial cable, or fiber optics) or wireless (WiFi, cellular or satellite)
   - Devices (routers, switches, and access points)
3. Rules to manage the flow of a service's data through the infrastructure — the **Protocols**
   - A common "language" that the hosts and devices use to pass data through the network
   - Security policies and safeguards to protect the data on the network
4. Devices that provide and/or use the services that are to be shared — the **Hosts**
   - Server/Client network model where servers provide network services and clients use the network services
   - Peer-to-Peer network model where most hosts are functioning as both a server and client

Biotechnology Scenario

Sofia is a Biotechnology Technician hired as part of a nationwide research team studying biofuels. Her work in the lab will involve conducting experiments using high tech equipment with specialized software to transfer data from the equipment directly to a database. Her team also needs to share and access data from other biofuels labs across the country. Her lab manager hired a company to design and build a Client/Server network with cloud storage and asked Sofia to brief their network architect on the project's current activities and anticipated network needs. With Sofia's input, the network architect was able to design, build, and configure an integrated network using a diverse set of infrastructure devices, a combination of protocols, and multiple networking services. She also worked closely with the network security administrators to make sure it and all the data that passes through it are secure.

Manufacturing Scenario

Blake is a Controls Technician at a heavy equipment assembly plant and has recently received approval from his supervisor to work from home two days a week using remote monitoring software that he can access via the Internet, 24/7. There is currently poor Internet access where he lives, but a state agency bringing broadband technologies to rural areas has dispatched Keisha, a Broadband Technician, to set up the network infrastructure to remedy that situation. At Blake's house, she installs a small utility box called an optical network terminal (or ONT) inside the home attached to a wall. She then installs cable from a nearby equipment box outside to the ONT, which typically requires running cable along floors or the ceiling inside the home. Once the cable work is done, Keisha sets up the router which connects to the ONT. Before she leaves, she tests the internet connection and confirms that Blake knows how to connect via Wi-Fi to the router from his computer and other devices. After following his company's security protocols for logging in, he can now access real-time sensor data from his home office.

NETWORK ARCHITECTURE

Activity

This activity is designed to help students visualize the basic structure of a network. Begin by showing a network diagram. Next, the students will watch a video on designing a small business or home network. Then they draw their best rendition of how the network is set up at their home or potentially could be designed.

Warm-Up

Review the vocabulary and concepts provided on the student card, then display this diagram of a network: Visual Paradigm Online. Ask student pairs to identify the familiar components of the network shown in the diagram:

1. Identify the network infrastructure and whether it uses physical or wireless media
2. Identify the infrastructure devices (routers, switches, and access points)
3. Identify the hosts (computers, printers, and multimedia devices)
4. Identify the network services used by hosts (file, print, messaging)

Activity Steps

1. Ask students to think about the networks that they are familiar with in homes, classrooms, and workplaces.
2. Have them watch this video, Designing a Basic Small Business or Home Network (5:44), that demonstrates the options for how a small network can be configured.
3. Ask them to reflect on a network discussed in Step 1 and then draw a rough diagram of it.
4. Students can then share and explain their diagrams.

Network Archicture Competencies

- Designing and installing computer networks, connections and cabling
- Troubleshooting system failures and network infrastructure problems
- Configuring software/firmware on the hosts and infrastructure devices
- Maintaining and repairing host and infrastructure devices
- Preserving high levels of network security
- Staying informed about new network technologies

Cross-disciplinary Skills

- Collaborating with others
- Communicating network access and usage policies
- Following industry-specific regulations related to security
- Seeking ongoing process improvements

Read More

- The Fundamentals of Networking

ABOUT THE PROJECT

Preparing Technicians for the Future of Work, funded by the National Science Foundation Advanced Technological Education program, recognizes that technicians need an expanded skill set to remain competitive. The project's Framework for a Cross-Disciplinary STEM Core outlines recommendations for incorporating knowledge and skills in Advanced Digital Literacy, Data Knowledge and Analysis, and Business Knowledge and Processes. Learn more about implementing the Framework at preparingtechnicians.org.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

What Are Artificial Intelligence and Machine Learning?

Artificial Intelligence (AI) is software that allows computers to simulate human reasoning, learning, and problem solving. (source) Machine Learning (ML) is a type of AI that gives a computer the ability to identify patterns to make predictions and decisions without human assistance. (source) ML uses mathematical models of data to help a computer learn without direct instruction. Many consumer products and services, such as autonomous vacuums, navigation apps, and voice-controlled intelligent personal assistants rely on AI. STEM technicians in a variety of fields use AI and ML enabled equipment and processes, from exoskeletons boosting productivity in automotive plants to sensors that detect plant diseases or weeds and decide which chemicals should be applied in precision agriculture.

Vocabulary

- **AI chips**—semiconductors that are designed to handle the computation-heavy algorithms necessary for AI
- **Algorithm**—a series of steps followed in a specific order to perform a task; used to generate a Machine Learning model
- **Chatbot**—provides automated speech recognition and voice synthesis and carries out realistic conversations
- **Deep Learning**—a type of Machine Learning that enables computer systems to learn new knowledge and improve their functionality through experience rather than by being programmed
- **Neural Network**—a series of algorithms that are modeled after the connections in the human brain

How will technicians use AI and ML?

Imagine that every time you got in your car, the car remembered little things like how you took a corner or how you accelerated and braked. It remembered your driving habits and tailored future journeys based on past expeditions. When some machines operate over time, they remember what happened and adjust their next actions. This is how AI and ML enable predictive maintenance.

Manufacturing Scenario

Carlos is a Surface Mount Technician for a manufacturer of small surface-mounted electronic components. Equipped with those components, a pick and place machine that puts electronic components on the motherboard of your new cell phone, for example, might remember position, acceleration and deacceleration speeds, and vacuum nozzle data during the placement. If the vacuum head of the machine is not drawing the exact amount of air to pick up a part, the machine will stop and alert Carlos about the problem through its Human Machine Interface (HMI). Carlos can then stop the process and make adjustments or repairs, but this requires down-time of the machine. In limiting down-time, predictive maintenance is key. Using ML, the pick and place machine can predict there will be a problem even before it happens and alert Carlos to perform preventive maintainence. This saves the company money by minimizing the time the machine is offline.





ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Skills Needed for a High-Paying Career

- Basic programming
- Using probability and statistics
- Modeling and evaluating data
- Coding simple algorithms
- Employing analytical thinking skills
- Computational thinking
- Applying Machine Learning algorithms

Education

Your local community college provides the advanced technology classes you will need to get started. Currently there are very few associate degree programs in AI, but many of the skills needed are taught within Information Technology or Computer Information Systems programs. You will also find the skills applicable in a variety of technical specializations, such as biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of Artificial Intelligence and Machine Learning include:

- AI and ML models using expanded datasets
- Increased use of no-code ML
- ML technology offered through the cloud
- AI- and MI-enhanced cybersecurity
- Advanced applications using Natural Language Processing
- Emphasis on ethical and responsible AI
- Connected AI systems enabling ML algorithms to learn continuously
- AI-fueled technology advancements in transportation, healthcare, education, and customer service

Learn More

- Artificial intelligence (AI) vs. machine learning
- Can a neural network learn to recognize doodling?

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ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

What Are Artificial Intelligence and Machine Learning?

Artificial Intelligence (AI) is the simulation of human cognitive processes: learning, reasoning and self-correction. (source) Its foundations include mathematics, logic, philosophy, probability, linguistics, neuroscience, and decision theory. Many technologies use AI, including computer vision, robotics, machine learning, and natural language processing.

Machine Learning (ML) is a subfield of artificial intelligence. Its goal is to enable computers to learn on their own. A machine's learning algorithm enables it to identify patterns in observed data, build models that explain the world, and predict things without having explicit pre-programmed rules and models. (source)

AI and ML Competencies

- Using probability and statistics
- Modeling and evaluating data
- Coding simple algorithms
- Employing analytical thinking skills
- Computational thinking
- Applying Machine Learning algorithms

Cross-disciplinary Skills

- Basic programming
- Using statistical methods
- Data analysis
- Communicating effectively with diverse audiences
- Upholding ethical computing principles

Security Technology Scenario

Tiffany, a Network Technician working with the IT security department at a small company, was assigned to automate the manual tasks involved in monitoring the hundreds of networking devices. Each of the networking devices keeps a log or text file of the status of the network devices. When a security incident occurs the network device logs the attack. Without automation, several employees have to view each network device's log to react to the attack and protect the network. Tiffany installed a Machine Learning application that not only checked each log but also automated the steps necessary to defend the network. ML can also provide predictive analytics to enable early detection and remediation of threats.

Agriculture Technology Scenario

Maelynn is an Agricultural Technician for a major soybean producer. The company is instituting a Precision Agriculture Strategic Plan to use technology to conserve resources, such as fertilizer and water, while increasing crop yields and profitability. As part of this plan, Maelynn was tasked with finding new ways to identify unhealthy plants. She partnered with a data science technician to accomplish this by using a combination of drones and AI software tools. Drones were used to take photos of the soybean fields. The photos were assembled by GPS location and evaluated for dark or unhealthy leaves. The AI tools allowed the software to pinpoint the unhealthy plants in the pictures and send that GPS information to an autonomous tractor in the field. Instead of the autonomous tractor spraying the entire field, the AI software directed the sprayer to only cover the areas where the plants were not healthy. This AI process not only saves the company money on chemicals and water but is also better for the environment.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Activity

Students will investigate how Artificial Intelligence (AI) and Machine Learning (ML) could be used to solve problems in their field of study. To begin, they will develop a specific recommendation for how machine learning could contribute to solving one of these problems. Then, they will consider the training data an AI system would need to make this possible.

Warm-Up

Review the definitions of AI and ML. Watch the video Artificial Intelligence Explained in 2 Minutes, followed by Deep Learning to help students think about ways that AI and ML help society solve problems. Explain that today's activity will give them the opportunity to discuss this in the context of industries where technicians work.

Activity Steps

1. Tell students that they will investigate the potential of AI and ML in their field of study. Explain that the goal is to explore one problem where AI or ML technology has potential to innovate.
2. Have students work in pairs to identify a problem in their career field that might be solved using AI or ML.
3. Give students 20 minutes to conduct research on their problem.
4. When there are about 10–15 minutes left in the class period, allow each pair to share their findings.

Tools Available

- Try AutoML Google Cloud
- Scikit-Learn Machine Learning in Python
- Teachable Machine with Google

Read More

- What is Artificial Intelligence?
- An Introduction on Artificial Intelligence and Machine Learning
- Bytes of AI: Short Curriculum

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ENTREPRENEURSHIP

What Is Entrepreneurship?

Entrepreneurship is the concept of developing and overseeing a new business for profit. Working inside a company and thinking like an entrepreneur by asking "how can we improve this process?" is just as important. Entrepreneurship means thinking beyond troubleshooting or problem solving. It involves taking extra effort that yields potential new products, services, or processes.

Vocabulary

- **Entrepreneur**—An individual who starts a new business venture. Typically, the individual who takes on most of the risk and develops the business concept.
- **Venture**—A business enterprise in which the expectation of gain is accompanied by the risk of loss or failure.
- **Capital**—The wealth or assets available to invest in a business.
- **Business Model**—A description of how a business will be able to create and deliver value and become profitable.
- **Market Research**—Relevant data that helps demonstrate market potential for a business venture.
- **Intellectual Property**—Works or inventions that is the result of creativity to which one has rights and can apply for a patent, copyright, or trademark.

How will an entrepreneurial mindset be used in the workplace?

An Industry 4.0 technician of tomorrow needs creative entrepreneurial thinking as a new, expected skill. John Gruene is an automotive technician at Advanced Auto. Lately John and his team have experienced several customer complaints regarding repair times. Using an entrepreneurial mindset, John identified the problem and then researched possible solutions and their value propositions. He asked questions like: how much is customer satisfaction and loyalty worth? and how much time and money can be saved through more accurate diagnosis and efficient repair? He then approached his supervisor about a potential solution he has researched that will provide better customer service, shorter wait times, and fewer errors by the technicians, resulting in higher profits for the business.

In another example, Casey Sanders is a robotics technician at Cooper BioLogic, an automated filling and packaging company. Over the last seven days, a robot gripper has been dropping every hundredth vial. The fault affected everything down the line, to the point at which several boxes shipped to a customer were short a few vials. This is clearly not an acceptable business practice. Casey applied troubleshooting skills to determine which gripper was malfunctioning and replaced it. But next Casey went further and used an entrepreneurial mindset in thinking about the whole line. She calculated the current time from production to packaging and suggested that new technologies, such as soft grips, could be integrated into the process to increase efficiency and accuracy and decrease product time-to-customer.





ENTREPRENEURSHIP

Skills Needed for High-Paying Jobs Using an Entrepreneurial Mindset

- Thinking creatively, like an entrepreneur
- Researching (e.g. current products and markets)
- Networking strategically
- Solving problems and thinking critically
- Communicating clearly with all stakeholders
- Planning carefully and effectively
- Calculating finances accurately

Education

Your local community college provides the classes you will need. Skills for researching, planning, and starting a business based on an entrepreneurial idea are most often taught within a Business program but may also be included in an Engineering Technology or other technology program offering associate degrees and one-year certificates. Entrepreneurship skills are also important in other technical fields in which you might start a company, invent a machine or process, or provide services. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

- Design Thinking—Processes for designing products, buildings, and machines and for solving problems known and unknown
- Agility—The ability to shift priorities quickly
- Disruption—The effect on the market when when a new product "explodes" in popularity
- Mobile commerce—Buying electronically via website or app
- Home-based businesses—Online shopping, remote work, and the popularity of social media have made home based businesses thrive
- Niche markets—Customer focused businesses that can be tailored to defined markets of unique groups

Learn More

- Understand the Basics of Creating and Financing a Successful Business
- How to Write a Business Plan (video)
- Learning about the Entrepreneurial Mindset

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ENTREPRENEURSHIP

What Is Entrepreneurship?

Entrepreneurship is the process of starting a business or other organization. The entrepreneur develops a business model, acquires the human and other required resources, and is fully responsible for its success or failure. Entrepreneurship operates within an entrepreneurship ecosystem.

Entrepreneurship Competencies for Technicians

- Demonstrating consistent leadership
- Making decisions independently
- Staying focused and maintaining inner drive
- Computing company financial data -- costs and other business expenses; profit/loss, taxes, projected income, budgets, etc.
- Understanding marketing principles

Cross-disciplinary Skills

- Creating and interpreting spreadsheets
- Visualizing data
- Solving problems and improving processes through innovative solutions
- Understanding business cycles and supply/demand
- Demonstrating ethical behavior
- Managing time efficiently
- Communicating clearly, concisely, and persuasively to a variety of audiences, i.e. teams, management, clients, and suppliers

Manufacturing Scenario

Jane works as a technician at US Manufacturing. US manufactures customized components for the auto sector. The industry is extremely competitive, and US is looking for ideas on how to increase optimization, efficiencies, and develop new products. Jane approaches her supervisor about a concept she has thought about that would reduce their error rates on the production line. The process involves removing one step in the process and changing the flow of the hand-off of the product. She has researched the process, demonstrated that it can take 15 seconds off the time, and would like to see if the final step can assist the finishing team. Jane worked with management to help define how this could provide value to US and its customers.

IT Scenario

Jim works for LMN Cabling in the field as an installer. Daily he is bombarded with customer complaints regarding other technicians. He notices a trend that most of the complaints are regarding a challenge with a switch and how to use it. When he is approached by customers, he takes the time to review the process and makes sure they have a good understanding on how to use it. Jim takes the initiative to go to his manager and suggest developing a user card for all the installers to walk through with the customer following the install. Management supports the idea and has Jim train the team on using the card and including it as a final check of the completed installation.

ENTREPRENEURSHIP

Activity

The activity will place students in groups of 3-4 and assign them each a product, process, or service from their primary field of study. The students will be given instructions that the product is brand new to the market with preliminary market research on it. Students need to work collaboratively on creating a business plan.

Warm-Up

Introduce or review the components of a business plan. Show the 3-minute video, "How to Write a Business Plan" – a clear and concise overview of the elements needed. Entrepreneurs need to develop a business plan that ultimately serves as their guide with goals and objectives for their business. The process of developing a business plan includes identifying the problem the business solves, the market it serves, required resources, and financial planning and modeling. A thorough business plan will include in-depth market analysis, and financial projections to demonstrate the viability of the business concept.

Activity Steps

1. Students will be in groups of 3-4 and each group should determine a product, process, or service they wish to sell. (5 min)
2. Student teams will answer some essential questions about their business. (20 min)
   a. What products or services will our business provide?
   b. Who is our competition?
   c. Who needs or wants this product, process, or service?
   d. How large an investment will be needed to launch this start-up?
   e. How soon can our business start providing the product, process, or service?
   f. How many employees will we need at first?
   g. Who can we ask for advice about this venture?
3. Students will report out on their new business idea and share how they approached planning. (5 min)

The whole group responds to each business idea. Will they predict success or failure? Why? (10 min)

Tools for Creating a Business Plan

- A well-organized blank Business Plan creation template with very good instructions and explanations can be downloaded free from the SCORE site.
- Another tool is the Business Model Canvas. Read The Business Model Canvas Explained and then download the blank template.

Read More

Students may have questions about patents and intellectual property rights. They can learn more from the Small Business Encyclopedia. Additional ideas for teaching about entrepreneurship can be found in the NC-NET Employability Toolkit, Module 8.

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COMMUNICATION

What is Communication and how is it related to Business Knowledge and Processes?

Communication is how we give and receive information and convey our ideas and opinions. To communicate effectively, technicians need to develop verbal, written, and visual communication skills and active listening skills. They also need to be aware of the meaning conveyed by non-verbal communication cues. It is important to differentiate informal communication, which may be part of a one's social connections in the workplace, from formal communication. Formal communication requires consideration of the audience, the purpose, and attention to tone. This can help prevent miscommunication.

Vocabulary

- **Verbal** – communication through spoken sounds, word choice, tone of voice
- **Non-verbal** – communication through facial expressions, body language, posture, position in the room, movement
- **Active listening** – process of paying careful attention while hearing information and focusing on all of the content before responding
- **Written** – information conveyed through emails, reports, text messages and other written media
- **Visual** – information presented through signs, symbols, and graphic representations
- **Tone** – manner of expression in speaking or writing when used to express an emotion
- **Informal** – unofficial and spontaneous communication between leaders, colleagues, and others in the workplace
- **Formal** – the official interchange of information between leaders, colleagues, and others in the workplace
- **Miscommunication** – failure to communicate adequately

How will technicians use communication?

In her job as a manufacturing technician, Kate is part of wafer production team creating the very latest semiconductor chips to power PCs, tablets, smartphones, and wearable devices. To ensure a smooth transition between shifts, Kate verbally shares with the incoming technician a summary of what happened during her shift. There is a brief shift overlap which gives Kate plenty of time to talk about the typical daily production items. If there are any major problems that come up, however, Kate will need to provide documentation by writing a description of the problem, the root cause (if known), and whether it was resolved. She can do this through an email to her supervisor and the technician coming on board for the next shift. Kate includes a subject line stating the email is about a problem during her shift. She starts her emails with a formal salutation, using her colleague and supervisor's names. The body of the email is concise and to the point. Kate reviews her emails carefully before sending it out to ensure that it is free of errors and that she has used a professional tone.





COMMUNICATION

Skills Needed for a High-Paying Career

- Communicating verbally (phone calls, personal communication, professional conversations, presentations, interviews)
- Listens actively, asks clarifying questions, and summarizes information to check for understanding
- Comprehends written material
- Conveys information professionally in writing (reports, memos, emails, faxes, forms, letters)
- Responds carefully to nonverbal communication
- Selects the appropriate media for presentations (presentation slides, photos, graphics, drawings, video, audio recordings)
- Combines written, verbal, and media communication effectively (data visualization, training, team troubleshooting

Education

Your local community college provides the classes you will need. Skills for speaking and writing well are most often taught within courses as part of presentation skills but may be offered within courses required for the general education component of the associate degree or one-year certification or within workforce preparation coursework. Communication skills are critically important across all technical fields, including agricultural, cybersecurity, biomedical, energy, environmental, engineering technologies, etc. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future will include using communications skills in:

- Remote and hybrid work environments
- Meetings with higher definition video conferencing
- Artificial Intelligence, Augmented Reality, and Virtual and Augmented Reality collaboration platforms
- Wearable Apps
- A global economy requiring intercultural communication skills

Learn More

- Communication Skills at Work: 4 Key Tips (video)
- How to Communicate Better with Coworkers

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COMMUNICATION

What Is Communication?

Communication is the transfer of information to produce greater understanding. It can be done verbally (through words, vocal tone and pitch), nonverbally (through body language and gestures), visually (using graphs, charts, or maps), and through writing.

Communication Competencies

- Communicating verbally (phone calls, personal communication, professional conversations, presentations, interviews)
- Listens actively, asks clarifying questions, and summarizes information to check for understanding
- Comprehends written material
- Conveys information professionally in writing (reports, memos, emails, faxes, forms, letters)
- Responds carefully to nonverbal communication
- Selects the appropriate media for presentations (slides, photos, graphics, video, audio recordings)
- Combines written, verbal, and media communication effectively (data visualization, training, team troubleshooting)

Cross-disciplinary Skills

- Selecting the appropriate methods to communicate with diverse audiences
- Using visualization tools effectively to present data
- Proficiency with digital communication technologies
- Following ethical principles in the digital world

Information Security Scenario

Jayden is a Network Technician for an engineering consulting firm. Recently, the company had a cyber incident. One of the employees in the accounting department clicked on a link that she thought was from the IRS, but it wasn't. When she clicked on the link, she was asked to enter the company's login information, which gave cyber criminals access to their company's financial details. To prevent this type of incident from happening again, Jayden needed to communicate to all employees in a clear, concise manner about the danger of clicking on unsolicited email links and attachments and how to stay alert for warning signs of fraudulent emails. He did this by creating a one-page document with bullets that stated what not to do and why and the importance of contacting him if they receive suspicious emails. Jayden used 10 minutes of the company's weekly staff meeting to present the document and then followed up with an email and attached the document so everyone at the company would have access to both hard and electronic copies.

Energy Technology Scenario

Ray recently began a position as a Nuclear Operations Technician soon after graduating with an associate degree from a nearby community college. Ray works in the control room for a nuclear power plant and is spending the next year training with a more experienced technician. Gaining the technical knowledge from college has provided an essential foundation to his work but asking key questions now that he's on the job has been equally important. Ray carries an iPad with him to take notes and to document questions and answers throughout the day. After asking a question, he types notes on what he hears and sends the summaries back to his supervisor for verification. If what he heard demonstrates misunderstandings, Ray corrects his notes, then summarizes again to make sure he is on target. This is a practice he uses when he meets with engineers and scientists at the plant as well. Not only does it help Ray, but others at the company have shared that it helps them build confidence in Ray's abilities as a new technician.

COMMUNICATION

Activity

This activity asks students to explore how technicians use process writing. First, students to watch a video of a process. They create a written set of processes on their own then consolidate and finalize the process document with a partner.

Warm-Up

Review the types of communication. Explain that one type of communication technicians frequently use is written communication, such as emails, memos, lab reports or technical procedures for using equipment. Each of these types of writing requires a distinctive style based on purpose and audience. Discuss that procedural writing outlines process steps in the order they need to be completed. Well-written procedures are factual, precise, and provide the reader with adequate detail. It is important to write a draft or practice document before sharing it with others who will use the process. Ask students for examples of when they've used a procedural document such as a lab manual or Standard Operating Procedures (SOP) manual in the past and what made it effective or ineffective.

Activity Steps

1. Explain to students that the activity is for them to watch a procedure and translate it into written directions. Ask what procedural documents they might need to write in their fields.
2. Review or provide brief background on cobots. A cobot is collaborative robot typically used in advanced manufacturing. The activity will have students first learn how to program a cobot through watching a video and then write the procedure for programming a cobot.
3. Have students watch The Cobot: A Tutorial video all the way through.
4. Students watch the video again through 3:40, documenting the steps they are watching. They can stop the video and/or watch a few more times to write down all the process steps.
5. In pairs, students compare their steps. Together they should revise the procedure to ensure the documentation is clear, concise, free of errors, and could be submitted as a formal process write-up in the workplace.
6. Have pairs share their procedure steps with the class.
7. Questions to pose to close out the activity: (a) What were the similarities and differences in the procedure documents you and your partner created separately? (b) What are challenges or opportunities for doing this type of writing in your field of study?

Read More

- 12 Tips to Effective Communication in the Workplace
- Working Stronger and Smarter: A Handbook on Theory and Techniques for Developing Employability Skills for Technicians
- "Communication," from the Employability Skills Resource Toolkit

ABOUT THE PROJECT

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LEAN PROCESSES

What are Lean processes and how are they related to Business Knowledge & Processes?

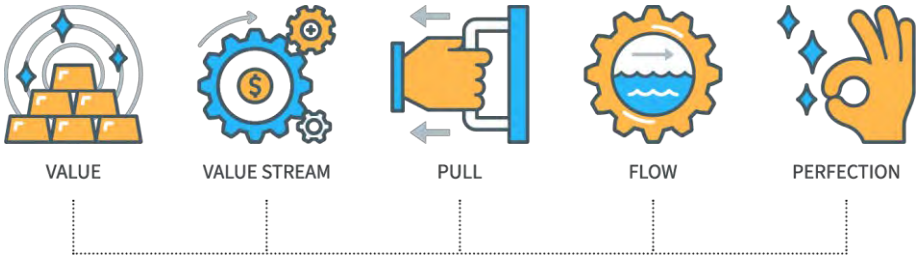
Lean processes focus on maximizing customer value while using fewer resources and minimizing waste. Lean thinking means always thinking about how processes and products can be improved.

Vocabulary

- **Continuous process improvement**—the ongoing improvements of products, services, or processes; related to the Japanese term **Kaizen**—improvement; good change
- **Efficiency**—the ability to achieve a goal with the least amount of waste
- **Waste** – materials or processes that are not creating value for the customer
- **Value** – what the customer is willing to pay for goods they want
- **Value stream** – all the steps in a work process that end with something a customer wants
- **Pull** – producing and delivering products and services when there is customer demand for them; related to the Toyota Kanban method
- **Flow** –ensuring steps in the value stream run smoothly without interruptions, delays, or bottlenecks
- **Perfection** – the overarching goal of meeting customer needs and striving to do it better each day (source)

How will technicians use Lean processes?

Amelia is a manufacturing technician for an automotive parts company. She has been recognized for her contributions to the company's delivery of quality parts on time to their customers. Recently, Amelia was becoming frustrated that her workstation was being left in disarray from the previous shift. This was impacting her daily production goals. She discussed this with her supervisor and found out there were other issues affecting productivity across shifts. Her supervisor facilitated a meeting with all the technicians to identify the root cause of the problems. Together they came up with a plan to address the decreased productivity. The last 10 minutes of a shift would overlap with the first 10 minutes of the next shift. Processes would not stop running—the flow (a critical principle of Lean manufacturing) would continue—but the technicians would have time to communicate important information, clean the work area, and check machinery (if needed). This change increased the company's manufacturing productivity and resulted in higher job satisfaction for Amelia and the other technicians.







LEAN PROCESSES

Skills Needed for a High-Paying Career

- Prioritizing what customers value
- Following company business processes
- Staying current with technological advancements
- Thinking creatively about how to solve problems
- Communicating effectively
- Demonstrating teamwork

Education

Your local community college provides the classes you will need. An understanding of Lean processes is most often taught within an Engineering Technologies, Advanced Manufacturing or Business associate degree program or in Management courses within general education requirements of an associate degree. Lean business processes affect all sectors of the economy, including businesses and industry in technical fields in which you might work or start your own company. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of Lean business processes includes:

- More small businesses adopting Lean processes
- Combining Lean business processes with advanced digital technologies like the Internet of Things
- Integration of big data
- Data-driven decision making
- Emphasis on problem solving, interpersonal skills and teamwork

Learn More

- What Is Lean Process Improvement?
- The Five Principles of Lean
- Why Use Kanban to Establish Pull Systems?

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LEAN PROCESSES

What are Lean Processes?

Lean processes are design to help businesses identify and eliminate waste, focus on the activities that create value for the customer, and ultimately, increase company profitability. The approach is based on the idea of continuous improvement and involves ongoing process adjustments to achieve better quality and flow, less time and effort, and lower cost.

Lean Processes Competencies

- Analyzing data to ascertain what customers value
- Following company business processes
- Staying current with technological advancements
- Thinking creatively about how to solve problems
- Communicating effectively
- Demonstrating teamwork

Cross-disciplinary Skills

- Selecting and utilizing appropriate analytics tools
- Conducting stakeholder analyses
- Instituting continuous process improvement
- Calculating Overall Equipment Efficiency (OEE)
- Communicating with internal and external stakeholders

Supply Chain and Logistics Scenario

Ezra is a Logistics Technician for a food supply chain company that provides warehousing and transportation services to restaurants, schools, and retail companies. Ezra is responsible for continuous process improvements in the warehouse. Ezra learned about an automation software program that would be a breakthrough improvement in helping the company better track their inventory without having to rework other processes or the layout of the warehouse. Radio Frequency Identification Data (RFID)-enabled plastic pallets would replace the company's current pallets. These special pallets have RFID tags inserted. RFID provides real-time visibility and location data specific to warehouse aisles, shelves, and shelf level locations. RFID would allow Ezra to track not just pallets and boxes, but the contents inside the boxes as well. RFID are a wireless technology, so Ezra does not need to do any scanning, making this an automated process. Ezra's company has been using the new pallets for one month and is already realizing more efficient inventory management and less waste.

Information Technology Scenario

Mariana is a Network Technician for a small construction company that is part of a network of local companies committed to Lean construction. The company was continuously seeking business process improvements to ensure customers receive the highest quality services at the best rates. Mariana knew her company would benefit from a new server given theirs was nearly five years old. Mariana researched the Environmental Protection Agency's (EPA) enterprise server efficiency levels product information on the Energy Star web site to inform their purchase of a new server. The Energy Star servers included must be priced no more than $118 than a less efficient model. An efficient product is cost-effective when the lifetime energy savings (from avoided energy costs over the life of the product, discounted to present value) exceed the additional up-front cost (if any) compared to a less efficient option. Servers have become higher performance and more efficient the past 3-4 years; therefore, the company could expect the savings to be even greater.

LEAN PROCESSES

Activity

This activity provides students the opportunity to explore Lean business processes and how they can be used in technician roles. Begin with the video and guiding questions in the warm-up. Next, have students review the infographic about Lean principles. Then, break students into groups to discuss the assigned technique and prepare for a brief presentation.

Warm-Up

Review the definition of Lean and examples from the scenarios. Have students watch these 2-minute videos: Five Lean Principles and Why Do Lean Manufacturing?

Ask students:

- What did you learn from the video?
- What examples of "Lean thinking" have you demonstrated personally, at school or at work?

Activity Steps

1. Begin by reviewing the definition of Lean and examples from the scenarios.
2. Have the students watch the video, then pose the questions in the warm-up to them.
3. Next, project the infographic, Five Lean Principles for Engineers, for students to review.
4. Break students into groups of 3-4 students. Assign each group a lean principle.
5. Have students discuss their Lean principle and how it could be applied to the work of technicians in their discipline or career of interest.
6. Have groups do a brief presentation to the class about application of their principle.

Tools Available

- The Plan-Do-Check-Act (PDCA) Cycle outlines four steps for managing continuous business assessment and process improvement. Continuous process improvement is a key feature of Lean practices. This free checklist walks you through the process.

Read More

- Lean Process Improvement: Achieving Project Success with Process Optimization
- Lessons in Lean Management for Any Industry

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SUPPLY AND DEMAND

What is supply and demand and how is it related to Business Knowledge & Processes?

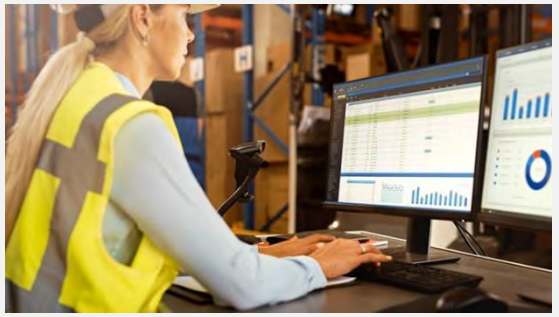
Supply and demand is the relationship between the amount of goods and services, or labor available and the amount customers want. Understanding supply and demand provides technicians insight into many of the business decisions of their employers, such as what products and services they offer, how much they charge, how the products and services are marketed, and potential plans to expand. The concept of supply and demand even impacts the number of technicians companies hire, salaries, and available career paths in a company.

Vocabulary

- **Demand** – The ability and willingness to buy a product.
- **Law of Demand** – If prices go up, demand goes down. If prices go down, demand goes up.
- **Supply** – The total amount of a good or service that is available to consumers.
- **Law of Supply** – An increase in price results in an increase in quantity. A decrease in price results in a decrease of quantity.
- **Supply Curve** – Demonstrates the supply of a product or service that would be available at different prices.
- **Economics** – The study of the production, distribution, and consumption of goods and services.
- **Market** – All of the buyers and sellers of a particular product or service within a region.

How will technicians use skills and knowledge related to Supply and Demand?

Maria is a Solar Technician in Florida. She had been very busy connecting new residential solar photovoltaic installations until recently and was wondering why fewer customers were choosing solar energy. She did some research and found out that the production costs of solar panels have risen over the past several months due to the jump in prices for two of the essential raw materials, aluminum and steel. In response, the manufacturer raised its prices on the panels it sold to the solar installation company. Maria's company needed to pass on the cost to customers, so the cost of solar panels increased. Fewer potential customers were willing to buy the panels at the higher price. Maria's analysis explained how the reduced supply of the materials impacted prices, and therefore, lowered the demand for residential solar energy.







SUPPLY AND DEMAND

Skills Needed for a High-Paying Career

- Analyzing data to forecast demand
- Interpreting financial spreadsheets
- Determining how current events will impact the market
- Identifying supply and demand, business cycles, and market trends
- Explaining processes impacted by supply and demand to a variety of stakeholders

Education

Your local community college provides the classes you will need. An understanding of supply and demand is most often taught within a Business program but may also be included in an Engineering Technology or other technology program offering associate degrees and one-year certificates. Supply and demand may also affect other technical fields in which you might start a company, invent a machine or process, or provide services. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

Supply and demand in the future will be impacted by:

- Direct sales to consumers which reduces costs and increases customer feedback
- Government policies that influence international trade altering supply and demand and consumer spending
- Challenges in finding talent, impacting expansion plans, and increasing automation and hiring outside of the U.S.

Learn More

- Difference Between Supply + Demand
- Economic Lowdown Podcast Series
- Infographic of Supply and Demand

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SUPPLY AND DEMAND

What Is Supply and Demand?

According to the Federal Reserve Bank, supply is the interaction between the quantity of a good or service that producers are willing and able to sell at all possible prices during a certain time period and demand is the quantity of a good or service that buyers are willing and able to buy at all possible prices during a certain time period. Supply and demand also apply to the labor market. It refers to the number of job openings and the number of individuals looking for work.

Supply and Demand Competencies

- Analyzing data to forecast demand
- Interpreting financial spreadsheets
- Determining how current events will impact the market
- Identifying supply and demand, business cycles, and market trends
- Explaining processes impacted by supply and demand to a variety of stakeholders

Cross-disciplinary Skills

- Creating and interpreting spreadsheets
- Using computational thinking strategies
- Interpreting statistics accurately
- Comprehending business practices
- Solving problems and improving processes
- Performing customer/stakeholder analysis

Automotive Scenario

When the tiny, two-seat Smart Cars first arrived in the U.S. in 2008, it was a time when gas prices were very high and consumers were looking at energy efficient alternatives in the car market. Dwayne, an Automotive Technician, began servicing these cars at his Mercedes-Benz dealer in early 2009. Since then, sales and service of Smart Cars have been dropping to the point where Smart Cars stopped being sold in the U.S. in 2019. Given the drop in demand, Dwayne now only works on 1-2 per Smart Cars per month. To ensure he has job security, Dwayne is taking Hybrid Electric Vehicle Technology courses at his local community college.

Agriculture Scenario

Sharon is an Agricultural Technician who serves several large farms in her town. She met with her clients recently to share how using global positioning systems (GPS) surveying can save them money by providing more accurate measurements of their field acreage. This is important since fertilizers applied via aerial applicators are charged on a per acre basis. Their current measurements are based on government estimates using aerial photographs, which are not precise. Sharon has a vendor that uses the latest GPS technology and has discovered that most of his other customers' fields are typically 5-10% fewer acres than they thought. That has meant 5-10% savings for the farms since they purchased less fertilizer. All of Sharon's clients decided to go with the GPS surveying, increasing the demand for this service in her area.

SUPPLY AND DEMAND

Activity

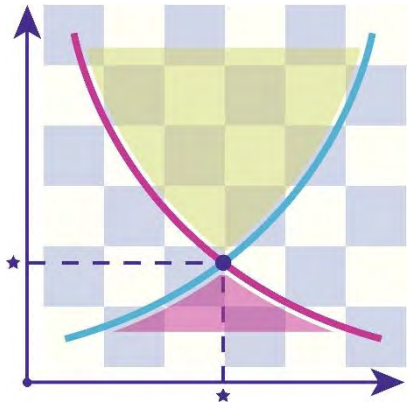
This activity focuses on the impact of supply of and demand for technicians. It provides the opportunity for students to explore a situation that is relevant to their future career paths. Begin with reviewing the definitions of supply and demand. Students will explore technician job projections on the U.S. Bureau of Labor Statistics Occupational Outlook Handbook online. They will discuss how their career path is impacted by supply of and demand for workers in their field.

Warm-Up

Show the 5-minute video The Labor Market, Economic Lowdown Series. Review the definitions of supply and demand and how they apply to the labor market. Provide the example of the nursing shortage and that U.S. hospitals are having difficulty finding nurses to fill the shifts. Hospitals are offering signing bonuses, flexible work schedules, and other benefits to entice nurses to choose them over other employers. This is also true for many technician positions. For automotive technicians, manufacturing technicians, and others, companies have increased their salaries and are offering additional benefits. In some cases, companies are signing employment contracts with students who are still in college and paying their tuition.

Activity Steps

- Students break up in groups of 3-5 to discover to discuss how supply and demand impacts their career paths.
- Students use the U.S. Bureau of Labor Statistics Occupational Outlook Handbook to locate the demand projections for their targeted occupation(s).
- Students find their occupation(s) and review the Number of Jobs, Job Outlook and Employment Change.
- Students discuss their findings in their groups.
- Students share what they discovered and how supply and demand impacts the world of technician careers as a class.



Read More

- Law of Supply and Demand
- Understanding the Labor Market

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