NC STATE UNIVERSITY

Developing STEM Identity in Rural Audiences through Community-based Engineering Design (DeSIRE)

NSF Abstract Award
Number: 1949454

DeSIRE Teacher Handbook

Advanced Manufacturing Course

for Middle School Students

Lesson Plans and KSA Resources

A collection of lessons plans and KSA (Knowledge, Skills, and Abilities) resources co-developed and collaborated with DeSIRE Program teachers.

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DeSIRE Teacher Handbook

Handbook Overview

This teacher handbook is produced as an essential reference and resource tool for DeSIRE teachers based on lesson plan materials (executed and proposed), grant purchased Do It Yourself (DIY) classroom STEM technologies, best practice hands-on activities for STEM Project-based Learning (PBL), industry professionals information presented on Advanced Manufacturing, and classroom content collaborated-on during annual 40-hour Professional Development summer workshops and throughout the academic year. This document is also infused with Knowledge, Skills, and Abilities (KSA) resources for teacher and student success.

DeSIRE teachers have the autonomy to adjust and edit collaboration-on all lesson plans and PBL activities to meet their daily classroom needs (i.e., time constraints, to meet student learner needs, and achieve intended DeSIRE goals using available resources). Lesson plan information is updated and infused with year-to-year teacher input experiences, recommendations, and best practices throughout the academic year and across the life of the grant, as needed.

Some DeSIRE purchased vendor STEM technologies, software, and DIY kits included lesson plans and activities. All of the resources are available for DeSIRE use and some are incorporated in this document (e.g., URL links, approved hard copies, vendor & company source references).

What is DeSIRE (Overview)?

DeSIRE is a partnership between the College of Engineering and the Friday Institute for Educational Innovation at North Carolina State University (NCSU), the NC Mathematics and Science Education Network Pre-College Program (MSEN), the Edgecombe County Public Schools (ECPS) district, and local advanced manufacturing industry. The Friday Institute (FI) is pleased to serve as the research partner for the DeSIRE project.

The goal of this four-year NSF-funded project is to create community-based engineering design experiences for underserved middle school students (grades 6-8) from rural NC aimed to improve their cognitive (STEM content knowledge and career awareness) and non-cognitive (interest, self-efficacy and STEM identity) outcomes, and ultimately lead to their increased participation in STEM fields, particularly engineering. DeSIRE overarching goals:

1) developing a 3-part Engineering Design elective course for grade levels 6-8 in which rural middle school students engage in engineering design experiences closely tied to local advanced manufacturing technologies and practices,

2) incorporating a mentoring component whereby undergraduate engineering students from the Minority Engineering Program (MEP) at NC State and STEM professionals from industry serve as mentors to the middle school students during the course and

3) providing In-depth STEM Experiences where students engage in supplemental STEM enrichment activities outside of the classroom such as industry and university tours.

Want to know learn about the DeSIRE NSF Grant:
https://www.nsf.gov/awardsearch/showAward?AWD_ID=1949454

DeSIRE Course Overview

Year-to-Year Grade Planning

The DeSIRE year-to-year classroom learning objectives and outcomes are essential and critical to student success and fulfilling the NSF grant requirements. Each year, the DeSIRE core classroom content overlaps, and advances in essential student learning outcomes.

6th Grade *(Year 1 - Fall & Spring)*	**7th Grade** *(Year 2 - Fall & Spring)*	**8th Grade** *(Years 3/4 - Fall & Spring)*
• Manufacturing vs. Advanced Manufacturing • Introduction to Advanced Manufacturing in the Food, Pharmaceutical and Energy Systems Industries • What is research? • Engineering Design Process • Introduction to Coding • Oral/Written Communication	• Advanced Manufacturing Technologies in the Food, Pharmaceutical, and Energy Systems Industries • Engineering Design in Manufacturing Environments • Introduction to MS Excel • Data Collection • Data Analysis and Interpretation • Preparing a Scientific Poster	• Advanced Coding • Advanced Statistics • Advanced Microsoft Excel • How do data analysis and interpretation drive business decisions? • Career Opportunities in Advanced Manufacturing • Career Opportunities in STEM • Preparing an Oral Presentation

Learning Outcomes: At the conclusion of the course sequence, students will be able to:

- Define manufacturing and discuss some examples of manufacturing tasks and processes.
- Explain the difference between traditional manufacturing and advanced manufacturing.
- Define the term research and discuss some examples of the importance and where used.
- Describe examples of research being conducted in advanced manufacturing and in STEM fields generally, and the potential impact of that research has on society.
- List some careers in the advanced manufacturing industry and in the various STEM fields.
- List and describe the steps of the engineering design process.
- Implement the steps of the engineering design process used in manufacturing processes.
- Demonstrate knowledge of basic systems, hardware, coding.
- Demonstrate growing proficiency in oral and written communication of technical content.

9-Week Pacing Guide

The DeSIRE course content and delivery pacing guide is based on a 9-week rotation synchronized with the school calendar. The learning module topics and deliverables below will ensure equal and proper coverage.

DeSIRE course weeks eight and nine are available and suitable for managing unplanned schedule disruptions, content and deliverables overflow, lesson plan adjustments, and school administration requirements and schedule changes.

Week#	**Energy Systems**	**Food Production**	**Pharmaceutical**
1	Introductions	Introductions	Introductions
2	Inquiry and Research		
3	Mock Adv. Manufacturing PBL Activities		
4		Inquiry and Research	
5		Mock Adv. Manufacturing PBL Activities	
6			Inquiry and Research
7			Mock Adv. Manufacturing PBL Activities
8	**Class Preparation for:** Final Projects & Student Presentations	**Class Preparation for:** Final Projects & Student Presentations	**Class Preparation for:** Final Projects & Student Presentations
9			

Creating Mock Advanced Manufacturing Learning Environments

The DeSIRE course content delivery methods include multiple STEM Education best practice learning models (i.e., project-based learning, contextual learning, and experiential learning) to achieve a foundational understanding of advanced manufacturing operations and practices.

The learning methods will help the learners achieve an effective application of hands-on practice of the 4Cs (i.e., communication, critical thinking, collaboration, and creativity) that are required for an effective STEM education and industry innovation success.

The DeSIRE teachers should strive to set up and implement team-based mock advanced manufacturing learning and work environments to emulate and simulate authentic industry experiences in production.

Below are five key areas of advanced manufacturing processes that should be discussed and included in mock project-based learning whenever possible to simulate real workplace activities.

Advanced Manufacturing Mock Simulation Learning Environments		
1	**Supply Chain Management Planning**	Budgets, Suppliers, Raw Materials, Assembly line Processes, Technologies, Schedules, Production Volumes, End-Product, Customer Experience (buying and using the product)
2	**Manufacturing Operations Management**	Project and Process Management, Cost Management, Quality Controls, Laws and Regulation requirements for the End-Product (i.e., Local/City, County, State, Federal, and International impact)
3	**Production & Process Flow and Cycle time Design**	Manufacturing Engineering Team Members (Industrial, Hardware, Software, Investments in Equipment and Advanced Technologies
4	**Engineering Design** *(Systems, Sensors, Data Collection - Analysis and Monitoring)*	Industry 4.0 Applications (e.g., AI, Internet of Things, Robotics, Human-Machine Interface). Usage of appropriate sensors (e.g., distance, temperature, light, sound, touch, presences, chemical), data management tools (e.g., spreadsheets, databases, Apps.)
5	**Team and Project-based Work Environment**	Production Plans versus Actual Results (Budgets, Costs, Expenses, Schedules, Volumes, Quality Defects, Labor/Workers

Curriculum and Lesson Planning

Infusing KSA driven learning

Broadly speaking, the role of the DeSIRE teacher is to help students learn and appreciate careers in STEM professions, college preparedness, and self-efficacy through the exploration and importance of advanced manufacturing in our society. By imparting knowledge on the core DeSIRE program attributes and other K-12 student essentials, students will learn and be effective in developing many skills for the workplace and in life (e.g., critical thinking, collaboration, communication, technology & information literacy, leadership, social skills, research methods).

KSAs (Knowledge, Skills, and Abilities) are used to help assess the qualifications and personal attributes required to perform a job. By infusing KSA supported learning, the DeSIRE teacher can help guide and nurture students to appreciate the importance of teamwork, getting and maintaining a job, and workplace experiences in advanced manufacturing and STEM careers.

- **Knowledge**: Help students develop STEM literacy through study and hands-on project-based learning on advanced manufacturing. Use the engineering design process to apply critical thinking and creativity in problem-solving. Showcase the importance of college.
- **Skills:** Help promote teamwork learning and hands-on experiences, capabilities, and proficiencies in STEM applications. Help develop practical & theoretical-based thinking.
- **Abilities:** Help students discover and cultivate talents, special gifts, and innate trait abilities to manage tasks and challenges in life and STEM. Showcase the importance of perseverance, hard work, and managing failures.

6th Grade – Year 1 Focus Topics (Fall & Spring)

- Manufacturing vs. Advanced Manufacturing
- Introduction to Advanced Manufacturing in the Food, Pharmaceutical and Energy Systems Industries
- What is research?
- Engineering Design Process
- Introduction to Coding
- Oral/Written Communication

7th Grade – Year 2 Focus Topics (Fall & Spring)

- Advanced Manufacturing Technologies in the Food, Pharmaceutical, and Energy Systems Industries
- Engineering Design in Manufacturing Environments
- Introduction to MS Excel
- Data Collection
- Data Analysis and Interpretation
- Preparing a Scientific Poster

8th Grade – Year 3 Focus Topics (Fall & Spring)

- Advanced Coding
- Advanced Statistics
- Advanced Microsoft Excel
- How do data analysis and interpretation drive business decisions?
- Career Opportunities in Advanced Manufacturing

- Career Opportunities in STEM
- Preparing an Oral Presentation

At-A-Glance: Teacher Talking points and Highlights

What is STEM Education?

STEM (Science, Technology, Engineering, Mathematics) education is an interdisciplinary approach to learning that combines the subjects of science, technology, engineering, and mathematics. The goal of STEM education is to prepare students for the real world by developing practical skills and the ability to understand complex problems.

What is Engineering?

There are many varying definitions on what engineering is. Here are some most notable:

- Engineering is the use of math and science to design, build, and test machines, structures, and processes to solve problems.
- Engineering is a branch of science that deals with the design, building, and use of engines, machines, and structures.
- Engineering is a discipline dedicated to problem solving.
- Engineering is exciting (hands-on, critical thinking, innovation, creativity, and teamwork)!

Engineers are problem solvers. Engineers are trained professionals who use scientific principles to solve problems by designing, building, and testing machines, structures, and systems.

What is Manufacturing?

Manufacturing is the creation of finished goods through the use of tools, human labor, machinery, and chemical processing. Manufacturing can be defined and classified under different types, processes, or techniques.

Manufacturing allows businesses to sell finished products at a higher cost than the value of the raw materials used. Large-scale manufacturing allows for goods to be mass-produced using assembly line processes and advanced technologies as core assets. Efficient manufacturing techniques enable manufacturers to take advantage of economies of scale, producing more units at a lower cost.

Before the Industrial Revolution, most manufactured products were handmade using human labor and basic tools. Today, advanced manufacturing has greatly increased productivity.

What is Advanced Manufacturing

Advanced manufacturing is the use of new technologies, processes, and materials to create and improve productivity. It can also refer to the use of established techniques in new ways.

Advanced manufacturing can help reduce waste, improve efficiency, and create more environmentally friendly products.

Examples of Advanced Manufacturing

- **Internet of Things (IoT):** In advanced manufacturing, the IoT is a system of connected devices, sensors, and software that allows manufacturers to collect, analyze, and exchange data to improve efficiency, productivity, and safety.
- **Robotics and Automation**: Robotics and automation play a critical role in advanced manufacturing. Systems facilitate heavy lifting and precision movement, contributing to improved efficiencies and productivity.
- **Additive Manufacturing (AM)**: Also known as 3D printing, it involves creating objects by adding materials layer-by-layer. 3D printers enable precise, repeatable production of complex geometries, making it an ideal solution for high-strength alloys and recyclable plastics, and other materials.
- **Advanced and Composite Materials**: The development of advanced and composite materials has broadened the range of potential applications in advanced manufacturing. Innovations in high-strength alloys, recyclable plastics, and other materials can enhance durability, promote sustainability, and reduce overall production costs.
- **Nanotechnology:** Nanotechnologies have enabled the manipulation of materials at the atomic and molecular levels. This technology enhances various properties, such as strength, conductivity, or chemical resistance.

Manufacturing vs. Advanced Manufacturing

Traditional manufacturing processes and operations require human (manual) labor and use older methods and technologies. The methods are typically less nimble and adaptive and not optimized for creating large quantities of identical goods. Most processes and operations are rigid making change to existing workflows more costly and time-consuming for the buying consumer

Advanced manufacturing is a type of manufacturing that uses modern technologies to create products and improve efficiency. The main differences include the usage of:

- **Technologies** like automation, artificial intelligence (AI), the Internet of Things (IoT), data collection and analysis, and 3D printing.
- **Efficiency** methods and processes for faster production times, reduced waste, and enhanced output performance.
- **Flexibility** allows for quicker adaptation to change and varying workload and supply needs.
- **Workforce** requirements are smaller, more highly skilled workforce with expertise in data analysis, technology, and engineering.
- **Logistics** that enable expanded domestic and global supply-chain management and distribution channels to increase business sales and opportunities.

Advanced Manufacturing Technologies in the Food, Pharmaceutical, and Energy Systems Industries

Research and explore each industry:

- Manufacturing Engineers (Computer, Electrical, Industrial, Mechanical, Mechatronics)
- Manufacturing Managers (Project Manager, Process Manager, Logistics Planners)
- Manufacturing Processes (Discrete Manufacturing, Repetitive Manufacturing, Batch Process Manufacturing, Continuous Process Manufacturing, 3D Printing)
- Compare and contrast industry commonalities (required):
    - Primary professional career skills and jobs (list any special skills required)
    - Primary equipment and technologies
    - Key operations and processes to manufacture products
    - Key Manufacturing locations – Domestic, International
    - Market share in their industry
    - Does the company manufacture products for other companies or businesses?
    - Does the manufactured product require any government approval to sale?
    - How are the manufactured product(s) typically distributed to stores/customers?
    - What did you learn most about these products, companies, and industry?

Engineering Design in Manufacturing Environments

The DeSIRE Advanced Manufacturing course defines "Engineering Design in Manufacturing Environments" as a way to promote learning and experiencing hand-on applications using the engineering design process, authentic advance manufacturing workplace jobs and careers roles, processes, operations, and engage with industry professionals and university mentors.

Research and Exploring Advanced Manufacturing Technologies :

- Investigate Food, Pharmaceutical, and Energy Systems production companies.
    - What are the primary products are produced?
    - Select one product from each industry to research and study.
    - Using the Engineering Design Process, create a "mock" manufacturing environment and produce that "mock product."

Introduction to MS Excel

The DeSIRE Advanced Manufacturing course defines "Introduction to Microsoft (MS) Excel" as a way for students to learn about spreadsheets, including Google Sheets.

By a definition, a spreadsheet is a tool that is used to store, manipulate and analyze data. Data in a spreadsheet is organized in a series of rows and columns and can be searched, sorted, calculated and used in a variety of charts and graphs.

Learning Goals:

- Identify the main parts of the Spreadsheet (Excel or Google Sheets) window.
- Identify the purpose of the commands on the menu bar.
- Work with the buttons on the toolbar.
- Explain the purpose of options available for printing a spreadsheet.
- Enter and format text and numbers into cells.
- Successfully move from one cell to another containing formulas and text.
- Copy, Cut and Paste text and formulas.
- Understand cell references.
- Perform basic mathematical operations in a spreadsheet.

DeSIRE student learners should engage in spreadsheet project-based learning activities to experience math used in advanced manufacturing to develop critical thinking and operations.

Examples include: (1) calculating production volumes over time (days, weeks, months, year), (2) calculating product per unit cost times unit purchase cost, and (3) calculating expenses per product.

Data Collection

The DeSIRE Advanced Manufacturing course defines “Data Collection“ as a way for students to learn about data capture methods and usage for specific purposes.

By a definition, data collection or data gathering is the process of gathering and measuring information on targeted variables in an established system, which then enables one to answer relevant questions and evaluate outcomes.

DeSIRE student learners should engage in data collection project-based learning activities to experience data and math methods used in advanced manufacturing to develop critical thinking and operations. Examples include data collection and creation for customer surveys and observations, engineering team focus group questionnaires, online tracking data, experiment(s) data, secondary data analysis, and product transactional tracking and graphing.

Data Analysis and Interpretation

The DeSIRE Advanced Manufacturing course defines “Data Analysis and Interpretation“ as a way for students to learn about data analysis and interpretation methods and means for specific purposes.

By a definition, data analysis and interpretation is the process of using data to identify patterns, trends, and explaining and using those patterns to make predictions or draw conclusion.

Data analysis and interpretation are a critical part of many professions, including business, science, engineering, and medicine. For example, an advanced manufacturing company might use data analysis to calculate production volumes over time (days, weeks, months), predict sales figures, predict product defects expenses. A pharmaceutical engineer might study the effects of a new drug.

Here are some steps in the data analysis and interpretation process:

- Determine best use tools (spreadsheet, word processor to document report)
- Define objectives and questions
- Collect data
- Clean data
- Analyze data
- Interpret and visualize data
- Tell a data story

DeSIRE student learners should engage in data analysis and interpretation project-based learning activities to experience data and math methods used in advanced manufacturing to develop critical thinking and operations. Examples include data collection with data analysis and interpretation to better understand an engineering problem or manufacturing issue.

Preparing a Scientific Poster

The DeSIRE Advanced Manufacturing course defines “Preparing a Scientific Poster“ as a way for students to learn how to create and present a scientific poster for specific purposes.

By a definition, a scientific poster needs to be concise, compelling, organized, legible, and readable.

DeSIRE student learners should engage and learn to present scholarly work and research. Learn that research presentations and scientific posters can take a number of different formats.

Creating an effective scientific poster

- **Showcase the content of your research -** Include all parts of a lab report. Highlight the essential findings.
- **Introduction -** Include only the need-to-know information to set up the background and context.
- **Methods -** Describe your experimental set-up and protocol. Consider using a figure or flowchart as a summary piece.
- **Results -** This is the focus of the poster. Describe the results and analysis. Showcase your figures and charts. Remember to include figure captions to facilitate understanding.
- **Discussion and Conclusion -** Explain what the results mean in a broader context. Refer back to your results and hypothesis. You can connect your findings to future opportunities for research.
- **References -** Include citations for any works you have referenced. Use a bibliography and embedded citations.

Advanced Coding

The DeSIRE Advanced Manufacturing course defines “Advanced Coding” as writing code to perform complex and specific tasks and applications related to advanced manufacturing. Also, it helps students understand basic computer science knowledge which encompasses coding and software programming. The topic goal is to help students become better coders and increase their knowledge about various areas of computer science. Some learning should include:

- Write and use code to control complex circuits or technologies (robotics, sensors)
- Able to read and interpret code functions and operations
- Make a flowchart or handwritten diagram of the code operations or functions
- Rewrite (Repurpose) code for a different purpose to save time or make improvements
- Type many lines of code without spelling or syntax error
- Debug error messages quickly and without help
- Use complex commands to reduce lines of code (e.g., If statements, variables,)
- Help and support other classmates with coding questions and concerns

Advanced Statistics

The DeSIRE Advanced Manufacturing course defines “Advanced Statistics” as using and applying advanced math concepts and applications in statistical formulas and methods to perform complex and specific tasks and applications related to advanced manufacturing. Also, to help students appreciate the importance of advanced mathematics to solve complex problems in our society, including advanced manufacturing. The topic goals are to help students improve math performance skills, explore new areas of math, and prepare for advanced standardized testing, such as ACT and SAT tools. Some learning should include:

- Use statistical math and methods to solve problems related to everyday life and advanced manufacturing.
- Reading graph data from various plot types (graph data
- Generating data for graphing
- Use statistics to solve complex numerical)
- Help and support other classmates with math and statistic questions and concerns

Advanced Microsoft Excel

The DeSIRE Advanced Manufacturing course defines “Advanced Microsoft Excel“ as a way for students to learn about spreadsheets, including Google Sheets.

- Use advanced formulas and calculations. Linking pages. Using range methods

How do data analysis and interpretation drive business decisions?

The DeSIRE Advanced Manufacturing course defines “Data Analysis and Interpretation“ as a way for students to learn about data analysis and interpretation methods and means for specific purposes.

- Use advanced questions to evaluate business data typical to advanced manufacturing (production volumes, expense costs, number of processes, and process cycles.

Career Opportunities in Advanced Manufacturing

The DeSIRE Advanced Manufacturing course has created these student talking points.

Manufacturing is imperative to the U.S. economy, and has been deemed “a vital engine of our economic growth, innovation, and competitiveness” by the U.S. Department of Defense.

American manufacturers contribute more than $2.35 trillion to the national economy, making it the most impactful sector today. Manufacturers are essential, and so are their employees.

Some Advanced Manufacturing career options and jobs

Computer-aided design (CAD) *technician* - National average salary: $56,189 per year

> Primary duties: CAD technicians often study industrial technology and technology management, using CAD software to design and manufacture products and organize and perform production runs. They develop expertise within the CAD software and can use it to manufacture a variety of products.

Computer hardware engineer - National average salary: $106,813 per year

> Primary duties**:** Computer hardware engineers conduct research and lead development of hardware systems, parts and overall functionality. They test all components, establish production specifications and upgrade older systems to be compatible with newer ones.

Electrical engineer - National average salary: $95,119 per year

> Primary duties: An electrical engineer creates, builds and tests electrical systems, from small devices like a computer keyboard to large items like vehicles or airplanes. They develop electrical testing methods to establish quality assurance, improve production through establishing more efficient ways to use electrical power, manage projects or research and ensure all required codes and safety standards are met.

Electronics technician - National average salary: $54,352 per year

> Primary duties: An electronics technician helps engineers develop and design electrical products, components and parts. They create prototypes and use diagnostic tools to test, review or repair equipment and products.

Fabricator - National average salary: $53,175 per year

> Primary duties: A fabricator creates a finished product by assembling parts according to instructions. They inspect the finished item and complete quality assurance. Being a fabricator requires the ability to read blueprints and renderings, understand the latest technology and have dexterity to put fitting parts together.

Machinist - National average salary: $61,741 per year

> Primary duties: Machinists create metal parts, tools, components and instruments by using specialized and sophisticated computer-controlled machine tools, lasers or water jets. They follow blueprints and renderings from computer-aided design (CAD) and can produce one unique item or a batch of many quantities.

Mechanical engineer - National average salary: $89,424 per year

> Primary duties: Mechanical engineers design and supervise the manufacture of machines, products and components for a variety of uses or industries, like elevators, escalators, helicopters, electric generators or medical equipment. They analyze, test and interpret schematic drawings to best execute production.

Mechatronics engineering technician - National average salary: $72,901 per year

> Primary duties: Mechatronics engineering technicians apply mechanical, electrical and computer engineering theories and principals to modify, develop and test machines and equipment used in various parts of the manufacturing process.

Robotics engineers - National average salary: $107,080 per year

> Primary duties: Robotics engineers design, build, program and test complex electromechanical robots and automation devices that are used in manufacturing. They create new designs or enhance and update existing ones for improving efficiency.

Career Opportunities in STEM

STEM Shortage

The current shortage of professionals with STEM degrees, combined with the growing diversity of our nation's population, has provided incentive to US businesses seeking STEM talent to pay close attention to gender, racial, and ethnic diversity at every level.

Girls in STEM

Girls and minorities are more eager to join STEM than we may realize, and their potential is limitless. In NAF's STEM academies, 41% of students are female and 67% are from minority backgrounds.

STEM Careers: Everything You Need to Know

https://www.bestcolleges.com/careers/stem/

Benefits of Pursuing a STEM Career

- Many STEM jobs boast above-average median salaries
- According to the Bureau of Labor Statistics (BLS), the median annual salary for all computer and information technology jobs was over $100,000 in 2023.
- Demand for STEM professionals is rising
- The BLS projects 11% growth in STEM jobs between 2022 and 2032. This need for more STEM workers is primarily fueled by ongoing tech advancements and the growing use of artificial intelligence.

Science Careers

Science involves understanding and analyzing the natural and physical world around us. As a science major, you can pursue jobs in fields like biology, astronomy, environmental science, physics, and so on. Some science fields may require you to earn a graduate degree.

10 Popular Science Jobs			
Jobs	**Minimum Degree Required**	**Median Annual Salary (May 2023)**	**Job Growth Rate (2022-2032)**
Agricultural and Food Scientist	Bachelor's degree	$76,400	6%
Astronomer	Doctoral degree	$127,930	5%
Atmospheric Scientist	Bachelor's degree	$92,860	4%
Chemical Technician	Associate degree	$56,750	3%
Environmental Scientist	Bachelor's degree	$78,980	6%
Epidemiologist	Master's degree	$81,390	27%
Medical Scientist	Doctoral degree	$100,890	10%
Nuclear Technician	Associate degree	$101,740	-1%
Physicist	Doctoral degree	$155,680	5%
Zoologist and Wildlife Biologist	Bachelor's degree	$70,600	3%

Technology Careers

Technology careers offer the chance to work at the cutting edge of innovation. According to the BLS, jobs for computer and technology professionals are projected to grow far faster than the average for all jobs between 2022 and 2032.

In this STEM field, you could design and build software as a software developer. Or you could protect computer systems from cyber threats as a cybersecurity analyst.

10 Popular Tech Jobs			
Job	**Minimum Degree Required**	**Median Annual Salary (May 2023)**	**Job Growth Rate (2022-2032)**
Computer and Information Research Scientist	Master's degree	$145,080	23%
Computer Network Architect	Bachelor's degree	$129,840	4%
Computer Programmer	Bachelor's degree	$99,700	-11%
Computer Support Specialist	High school diploma or associate degree	$60,810	5%
Computer Systems Analyst	Bachelor's degree	$103,800	10%
Database Administrator	Bachelor's degree	$101,510	7%
Database Architect	Bachelor's degree	$134,700	10%
Information Security Analyst	Bachelor's degree	$120,360	32%
Software Developer	Bachelor's degree	$132,270	26%
Web Developer	Bachelor's degree	$84,960	17%

Engineering Careers

Engineering is all about using math and science to build computers, machines, buildings, and other structures. Popular engineering specializations include civil, mechanical, and electrical engineering. According to the BLS, architecture and engineering professionals earned a median salary of $91,420 in 2023 — that's over $40,000 more than the median salary for all jobs.

10 Popular Engineering Jobs			
Job	**Minimum Degree Required**	**Median Annual Salary (May 2023)**	**Job Growth Rate (2022-2032)**
Aerospace Engineer	Bachelor's degree	$130,720	6%
Chemical Engineer	Bachelor's degree	$112,100	8%
Civil Engineer	Bachelor's degree	$95,890	5%
Electrical Engineer	Bachelor's degree	$106,950	4%
Environmental Engineer	Bachelor's degree	$100,090	6%
Industrial Engineer	Bachelor's degree	$99,380	12%
Marine Engineers and Naval Architect	Bachelor's degree	$100,270	1%
Mechanical Engineer	Bachelor's degree	$99,510	10%
Nuclear Engineer	Bachelor's degree	$125,460	1%
Petroleum Engineer	Bachelor's degree	$135,690	2%

Math Careers

Math jobs generally entail using math fundamentals to analyze, calculate, and interpret data. You could become an actuary for a company to analyze cost and risk. Or you could teach math as a secondary or postsecondary educator. You'll need at least a master's degree to become a mathematician or statistician.

Popular Math Jobs			
Job	**Minimum Degree Required**	**Median Annual Salary (May 2023)**	**Job Growth Rate (2022-2032)**
Actuary	Bachelor's degree	$120,000	23%
Data Scientist	Bachelor's degree	$108,020	35%
High School Math Teacher	Bachelor's degree	$65,220 (all teachers)	1% (all teachers)
Math Professor	Doctoral degree	$81,020	3%
Mathematician	Master's degree	$116,440	2%
Operations Research Analyst	Bachelor's degree	$83,640	23%
Statistician	Master's degree	$104,110	32%

Preparing an Oral Presentation

The DeSIRE Advanced Manufacturing course defines and uses the term "Oral and Written Communication" as a way for students to learn, develop, and enhance verbal and written communication skills. The learning outcomes are to develop skills and abilities to articulate thoughts and express ideas effectively using oral, written and non-verbal communication skills (to inform, instruct, and persuade). The communications include effective listening for meaning and understanding.

DeSIRE student learners should engage in a wide range of oral and written communications projects (i.e., written technical reports and papers, slide presentations, technical demonstrations, STEM fair, Careers Fair, interviews with professionals, shadow experiences) to develop critical thinking, and team-based collaboration.

DeSIRE Safety Guidelines (Some Recommendations)

DeSIRE teachers and students are to comply with designated local school safety processes, procedures, and guidelines. Under the guidance of the DeSIRE school appointed teachers, staff, and administrators, it is recommended that teachers and students should:

- **Initial Safety Orientation:** Before the start of any DeSIRE PBL activity, provide a safety orientation to communicate any potential hazards and safety procedures.
- **STEM technologies usage and activity engagement**: No unauthorized experiments, modifications of equipment, or activities without teacher approval.
- **Personal protective equipment (PPE):** Wear goggles or safety glasses, gloves, and a lab coat when appropriate.
- **Work area**: Keep work areas clean and organized. Clean up after projects and return equipment to its proper storage area.
- **Behavior:** Be safe and responsible, and follow instructions. Do not run, push, yell, or fight.
- **Food and drink**: Do not eat, drink, smoke, chew gum, or put anything in or on your eyes, nose, lips, or mouth while in a lab unless approved by the assigned teacher(s).
- **Injuries**: Report any injuries, spills, or hazardous conditions to schoolteacher(s), staff, and/or administrators immediately.
- **Equipment:** Do not use equipment or tools without teacher approval.
- **Storage**: Do not open storage cabinets or enter the prep room without permission.
- **Safety zones**: Place safety zones around hazardous areas, such as some impact robotics and electricity and electronic projects.
- **Emergencies**: Know where safety equipment is located, including eyewash stations and emergency showers.

DeSIRE Keywords and Definitions

Notes to DeSIRE teachers:

These manufacturing, advanced manufacturing, and STEM product terms describe technologies, functions, procedures, systems, and methods that govern basic manufacturing and advanced manufacturing operations.

Some keywords and definitions may have been slightly altered for middle school aged learners and to fit-the context on the DeSIRE classroom objectives by the DeSIRE Professional Development training team. By teaching and understanding the basics of the industry, students will gain a greater understanding of how production processes work, technology tools and applications, and what can be done to make operations more efficient and cost effective.

Advanced Manufacturing - Use of innovative technologies to create existing products and the creation of new products. Advanced manufacturing can include production activities that depend on information, automation, computation, software, sensing, and networking.

Arduino - an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs (e.g., a light shining on a sensor, a button being pressed or released) and send output signals (e.g., turn on a motor, turn on an LED, or to publish something online). Users program (or code) the Arduino board by sending instructions to the microcontroller circuit chip on the board. To do so, users use the Arduino programming language (based on Wiring), and the Arduino Software (IDE - Integrated development environment) based on the Processing.

Assembly Line - The assembly line refers to the process where a product moves from one workstation to the next. Workers or automated systems add different components to the workpiece at each workstation. Once the product reaches the last workstation, you have a finished product. When you design an efficient assembly line, worker productivity increases as they use their time and labor more effectively.

Bill of Materials - Details all the raw materials used for the final assembly of the manufactured product. Items listed on the BOM include all the assemblies, subassemblies, and parts. It also features the exact number of items that will be used to complete the product, and defines the assembly path the product will take along the production line.

Cell - In a cellular manufacturing layout, you arrange equipment into small groups (or "cells") that make similar products or parts. Employees who work within a cell are typically cross trained to use all the equipment in the cell. This makes the production line more efficient and reduces production lead times.

Corrective Action Request (CAR) - Suppliers get corrective action requests (CAR) when problems are discovered with their products during the QA process. These notices provide details about the issues which help the supplier determine the cause of the problem. This way, they can take any corrective actions needed to remedy it.

Computer-Aided Manufacturing (CAM) - Computer-aided manufacturing (CAM) relies on the use of computer-controlled machinery and software to automate processes. Workers use this process automation to increase their productivity, since these systems lower the need for human intervention and allow workers to focus on other tasks.

Cycle Time - To understand the efficiency of workers and equipment in operations, you calculate the cycle time of production processes. Cycle time represents the time it takes to complete a product from start to finish. It begins when a product starts moving through the production line, and ends when the product is fully assembled and ready for shipment. The following equation determines cycle time: **Cycle time** = Total number of products / Total production time

Downtime - Downtime represents the timeframe when a process, machine, or cell stops production. This may happen due to an equipment malfunction that causes the systems to go offline.

Discrete Manufacturing - Discrete manufacturing refers to the production of products that are physically distinct, identifiable units. This is the manufacturing process used to create most finished products that you can buy in a store: computers, lawnmowers, cars, etc.

Energy systems (Technology) - "Energy systems technology" refers to the field of study and practice that focuses on the design, development, and implementation of systems for generating, converting, transmitting, distributing, and managing energy, including both traditional and renewable sources, with a primary emphasis on efficiency and sustainability across the entire energy chain; essentially, it's the technology behind how we produce, transport, and use energy in a comprehensive manner.

Good Manufacturing Practices (GMP) - Good manufacturing practices consist of guidelines, systems, and best practices for managing every aspect of the production process that impact the product's quality. This quality assurance system also ensures that manufacturers meet industry regulations so that products meet the highest possible standards.

Human-Machine Interface (HMM) - The human-machine interface consists of the user interface where the operator interacts with the machine. The operator may input data, monitor the machine, or make changes on how the machine performs work through this interface.

An integrated development environment (IDE) - a software application that helps developers write, compile, and test code more efficiently. IDEs combine many tools into one graphical user interface (GUI) to simplify the software development process.

Industry 4.0 - Industry 4.0 is a term used to describe the Fourth Industrial Revolution. It consists of the current manufacturing technologies, automations, and innovation trends. It encompasses both physical production processes and digital manufacturing processes to illustrate links between the two operations. Using the Internet of Things applications and technologies (e.g., smart sensors).

Machine Monitoring - Machine monitoring consists of software tools and technologies designed to monitor machine performance and collect performance data. Sensors attached to machinery transmit information about their utilization, which gives insight into how equipment is functioning and where repairs are needed. It can also help predict when maintenance is needed by collecting data over time.

Manufacturing - Manufacturing is the creation of finished goods through the use of tools, human labor, machinery, and chemical processing. Manufacturing can be defined and classified under different types, processes, or techniques.

Manufacturing USA - Manufacturing USA was created in 2014 to secure U.S. global leadership in advanced manufacturing by connecting people, ideas, and technology. Manufacturing USA institutes convene business competitors, academic institutions, and other stakeholders to test applications of new technology, create new products, reduce cost and risk, and enable the manufacturing workforce with the skills of the future.

Make to Order (MTO) - In the make to order (MTO) production strategy, manufacturers don't begin assembly until they get an order. This helps prevent manufacturers from having to rely too heavily on market demand (like the MTA and MTS methods) — which can be difficult to predict. The MTO process also allows for customization, as orders can be built to exact customer specifications.

Mean Time Between Failures (MTBF) - Mean time between failures (MTBF) refers to the average time that elapses between your equipment failures. You can calculate MTBF with this formula: **MTBF** = Number of operational hours / Number of failures

Mean Time to Repair (MTTR) -You use the mean time to repair formula to calculate how long it takes to repair machines or systems. This calculation takes into account both the repair time and the time it takes to perform tests, as this strategy goes hand in hand with MTBF. **MTTR** = Total maintenance time / Number of repairs

Original Equipment Manufacturer (OEM) - Original equipment manufacturer (OEM) refers to the manufacturer who originally makes the product that's marketed and sold by another company. An OEM is considered a business-to-business (B2B) company that normally does not sell products directly to consumers.

Performance % - Also known as throughput, performance percentage measures the actual cycle time for equipment, production times, or cells to meet the established schedule. You may use analytics software, which captures machine data as the software looks at the product counts and compares the figure to the system's ideal cycle time.

Programmable Logic Controller (PLC) - Workers use a programmable logic controller for specific manufacturing processes. A PLC is a programmed or modified computer that automates business processes, production lines, or machine functions. Using a custom program, the controller monitors and makes decisions for inputted devices.

Quality % - Simply put, manufacturers use the quality percentage metric to determine the quality of products produced by a specific machine. Analytical software can pull reject reason codes to determine why parts were rejected. From there, manufacturers can see which machines are producing quality parts and which are not.

Six Sigma - A quality measurement and data-driven approach designed to eliminate product defects. Using statistical models and empirical data, the approach allows manufacturers to enhance quality control and process compliance.

Standard Operating Procedure (SOP) - The standard operating procedure is a document that lists the steps used in the production process or the activities in a procedure. It ensures that your manufacturing operations meet regulations and maintain both performance quality as well as product quality.

Time to Market (TTM) - The time to market is the period of time from product conception to product release. This period of time includes product idea generation, the product design process, product development, and product launch.

Quality Management System (QMS) – A method that monitors operational controls, reports issues with processes, and documents improvements as well as manufacturing changes. The system is used to meet company regulations and customer requirements for all production processes.

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