Madison Public Schools
Biotechnology Curriculum

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Course Overview

Description

In this semester course students will be introduced to Biotechnology. Biotechnology involves the design of techniques and systems utilizing living organisms, or their parts, to accomplish some purposeful goal. Because of these links to science, biotechnology offers students a way to apply their knowledge of biology and other science concepts through a truly integrated STEM experience. In the first half of the course, students will focus on food production using aquaponic systems that we design, build, and test using the engineering design process. During the second half of the course, students will maintain and modify these systems to see how much produce they can yield. Throughout the course, there will also be smaller units such as prosthetics design and production.

Goals

This course aims to:

- Reinforce STEM concepts that students have learned in Biology and other STEM courses.
- Teach students to use the design process to efficiently solve problems
- Teach students to use technology and engineering concepts to

Materials

Core: Upstart University
Supplemental:

- Search Engines (Google)
- Urban Gardens
- Teach Engineering

Resources

Suggested activities and resources page

Benchmark Assessments

This course will consist of three benchmark assessments that will be given at the end of each major unit, this includes, Hydroponics, Water Filtration, and Prosthetics Design.

Modifications and Adaptations for Special Needs Learners

(Gifted and Talented Students, English Language Learners, Students with Special Needs, At-Risk Students, and Students with 504 Plans)

Scope and Sequence
(Pacing Guide)

Unit Number	Topic of Study	Duration (Weeks Taught)
1	Room Orientation/Safety Training	1
2	Introduction to the Engineering Design Process	1
3	Hydroponic/Aquaponic Plant Selection/ Germination and System Design	3
4	Hydroponic/Aquaponic Systems Fabrication	4
5	Hydroponic/Aquaponic System Adjustment and Monitoring	2
6	Water Filtration	3
7	Introduction to 3D Model	1
8	Prosthetics Design & Fabrication	4

Unit 1 Overview

Unit Title: Room Orientation & Machine Safety

Unit Summary:
In this unit, students will be learning where supplies and tools are located in the engineering lab. Students will also be trained on the proper techniques and procedures for using the different production machinery. Students will then be certified for use of these machines after successful completion of ITEEA's machine safety quizzes.

Suggested Pacing: 4-5 Lessons

Learning Targets

Unit Essential Questions:

- When is the proper time to wear eye safety?
- Who should know the lab safety procedures?
- How can I ensure my safety in the lab?
- What are the ramifications for not following lab safety procedures?
- How do I efficiently and safely operate the prototyping equipment?

Unit Enduring Understandings:

- Lab safety is important to everyone at all times.
- Safety is the most critical component of an optimum work environment.
- Understanding how to properly operate machines is a lifelong skill.

Evidence of Learning

Formative Assessments: Students will be assessed based on their cooperation and participation in class discussions and safety demonstrations.

Summative Assessment: Students will be assessed based on the scores they receive after completing the ITEEA safety test for each machine.

Alternative Assessments: Students will demonstrate their ability to properly follow safety procedures through a series of hand on test of their skills.

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Identify the proper times that they should be wearing eye protection. Identify situations where secondary eye protection may be required.	General lab safety procedures. Eye safety procedures. How to identify potential hazards. Vocabulary: Machine Guards, Primary Protectors, Machine Shields, Adjustments, Spectacles, Goggles, Welding Helmet	Students will be assessed based on their cooperation and participation in the class discussions, safety demonstrations, and the ITEEA safety test for general lab safety.	**RST.9-10.3.** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. **RST.11-12.7.** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in

			order to address a question or solve a problem. **9.3.MN-HSE.1** Demonstrate the safe use of manufacturing equipment.
Efficiently and safely use the portable, and stationary power and hand tools. Identify when a machine is operating properly and when it may need adjustment.	How to identify a machine that is functioning properly and one that is not. How to follow a proper procedure in order to safely and effectively use hand and power tools.	Students will be assessed based on their cooperation and participation in the class discussions, safety demonstrations, and the ITEEA safety tests for each of the stationary and portable machines in the engineering lab.	

Unit 2 Overview

Unit Title: Introduction to the Design Process

Unit Summary:
In this unit, students will be learning where supplies and tools are located in the engineering lab. Students will also be trained on the proper techniques and procedures for using the different production machinery. Students will then be certified for use of these machines after successful completion of ITEEA's machine safety quizzes.

Suggested Pacing: 1-2 Lessons

Learning Targets

Unit Essential Questions:

- What is the design process?
- How can we use the design process to help us invent & design?
- Why is it important to document our work?

Unit Enduring Understandings:

- The design process gives us a procedure to follow when problem-solving.
- There is always room for improvement when using the design process.
- Documentation helps us have the ability to recreate and improve our designs or the processes used to create them.

Evidence of Learning

Formative Assessments: Students will be assessed based on their cooperation and participation in class discussions.

Summative Assessment: Students will be asked to identify the different steps in the design process and the tasks that they should be performing during each step. Scoring will be done using the provided rubric.

Alternative Assessments: Students will complete the design process template with examples of different tasks that should be completed at each step.

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Use the design process to aid them in designing and creating their projects. Understand that documenting their work is one of the most important things engineers do.	The steps in the MHS design process. The proper format to follow when documenting their work. How to evaluate their work using the SWOT method. Vocabulary: Documentation, Design Process, SWOT Method, Evaluation, Constraint, Prototype, Viable	Students will be assessed based on their cooperation and participation in the class discussions.	**ITEEA: Standards for Technological Literacy 8H:** The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.

			8.2.12.E.4: Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types, and conditional statements). **8.2.12.C.7** Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.

Unit 3 Overview

Unit Title: Hydroponic & Aquaponic Plant Selection/Germination and System Design

Unit Summary:
This unit will introduce students to the idea of using water instead of soil as a medium to grow plants. Students will also choose the plants and vegetables that they want to design their system around, this is a crucial step in the design of the system because different plants have different requirements in a hydroponic system. Students will then begin researching and designing their own custom hydroponic or aquaponic systems.

Suggested Pacing: 10-12 Lessons

Learning Targets

Unit Essential Questions:

- What is a hydroponic & aquaponic growing?
- What types of plants can be grown in hydroponic & aquaponic systems?
- What types of hydroponic & aquaponic systems are there?
- What are the advantages and disadvantages of hydroponic & aquaponic growing?
- What conditions are needed for seeds to germinate?

Unit Enduring Understandings:

- History of hydroponic & aquaponic growing.
- How hydroponic & aquaponic growing work.
- Designs of systems that are currently in use.
- Pros and Cons of hydroponic & aquaponic growing.
- The process of germination.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed based on the viability of their design and the research they provide as proof of concept.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Understand the history of hydroponic & aquaponic systems. Identify the different types of hydroponics and aquaponics systems.	History of hydroponic & aquaponic growing. How hydroponic & aquaponic growing work. Designs of systems that are currently in use.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**ITEEA: Standards for Technological Literacy 15L:** Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. Biological processes are used in combination with physical technologies to alter or modify the materials, products, and organisms. Fermentation, bio-products, microbial

Decided which system effectively fits the needs of the plants that they selected. Germinate and start their seed for later use in their systems. Understand the advantages and disadvantages of hydroponic and aquaponic growing.	Pros and Cons of hydroponic & aquaponic growing. The process of germination. Vocabulary: Hydroponics, Aquaponics, Germination, Drip System, Wick System, Water Culture, Ebb, Flow, Nutrient Film, Medium, Aeroponics.		applications, separation and purification techniques, and monitoring and growth processes are key examples of biotechnology applications. Selection of genetically modified seeds, application of modified organisms (i.e., iceminus bacteria to prevent frost damage to plants), and uses of algal fertilizers generated from photobioreactors are good examples of extending agricultural practices through biotechnology applications. **8.2.12.B.4** Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants.
Design a hydroponics or aquaponics system using research and existing knowledge of biology. Select a plant or plants that are suitable for growth in a hydroponics system.	How to research different designs and types of hydroponic and aquaponic systems. How to design a system based on the unique needs of their selected plants.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.D.1** Design and create a prototype to solve a real-world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review. **8.2.12.D.3** Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development, and creation of a technological product or system. **CRP6**. Demonstrate creativity and innovation.

Unit 4 Overview

Unit Title: Hydroponic & Aquaponic Systems Fabrication

Unit Summary:
This unit will introduce students to the create phase of the design process. In this unit, students will build the hydroponic or aquaponic systems that they have spent the previous weeks designing. Students will use the fabrication machines that they were trained on in unit 1 along with their designs to fabricate their systems.

Suggested Pacing: 16-20 Lessons

Learning Targets

Unit Essential Questions:

- How can we use different materials to create our hydroponic & aquaponic systems?
- What extra steps can we take to ensure our hydroponic & aquaponic systems will not leak?
- How can we safely use the fabrication tools to create our designed systems?
- How can we break down this large project into manageable tasks?

Unit Enduring Understandings:

- How to properly use the tools and machines to efficiently and safely fabricate.
- Time management is a life skill.
- Updating your documentation as you go is the most effective method.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed based on the quality and efficiency of their work and how well its fits the provided set of criteria and constraints. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Create the systems they designed using industry-standard manufacturing equipment. Break down large projects into manageable tasks. Identify the proper materials to use int the fabrication of their systems. Ensure all safety rules are being followed during their use of the tools and machines.	How to safely and efficiently use the tools and machines to fabricate pieces of their systems. Manage the different roles of group members and the time table for each job. How to redesign or modify their systems when necessary.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.D.1** Design and create a prototype to solve a real-world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review**.** **8.2.12.D.5** Explain how material processing impacts the quality of engineered and fabricated Products. **HS-ETS1-2**. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Unit 5 Overview

Unit Title: Hydroponic & Aquaponic System Adjustment and Monitoring

Unit Summary:
In this unit, students will use the testing and evaluation portion of the design loop in order to determine the viability of their systems. Students will also use this time to make fine adjustments to their systems and monitor their performance. In some cases, it may be necessary to redesign the system entirely if the group deems the design to be majorly flawed. Students will also check nutrient and ph levels in their systems and adjust accordingly.

Suggested Pacing: 4-8 Lessons

Learning Targets

Unit Essential Questions:

- What small adjustments can we make to our systems in order to make it work more effectively?
- How do I keep track of my nutrient dosing?
- How do I regulate the PH of the system?
- How can I create a maintenance schedule so that my system performs at a peak level?

Unit Enduring Understandings:

- Fine tuning is imperative in order to have the systems operate properly.
- Ph and nutrients are controlled by carefully doing the proper chemicals and fertilizer.
- Over-fertilizing can have negative impacts on the systems.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed based on their ability to create and carry out an effective feeding regimen for their plants or fish. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Measure the ph of their systems. Create and carry out a maintenance schedule for their systems. Create a dosing schedule that is specific to their system and plants.	How to create a detailed schedule for both maintaining and dosing thier systems. How to redesign or modify their systems when necessary.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **9.3.12.AG-FD.1** Develop and implement procedures to ensure safety, sanitation and quality in food product and processing facilities.

Unit 6 Overview

Unit Title: Water Filtration

Unit Summary:
In this unit students will learn about the different types of water pollution and ways to prevent and remove these contaminants. Students will also design and build their own sediment filtration filter. Students will have the opportunity to test our their system using a bucket of water filled with both fine and coarse sediment.

Suggested Pacing: 8-12 Lessons

Learning Targets

Unit Essential Questions:

- What are the different methods of water filtration?
- What types of contaminants are in the water?
- What is the difference between mechanical, chemical, and biological filtration?
- How can we create a filter that will not quickly plug with heavy sediment?

Unit Enduring Understandings:

- Contaminated water is a global problem.
- Mechanical filtration is the removal of solids from the water.
- Chemical filtration is the removal of dissolved contaminants with a chemical process.
- Biological filtration is the removal of dissolved contaminants with bacteria.
- Proper engineering of water filtration products can result in longer filter life and more effective results.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed by their ability to research and design an effective mechanical filtration systems using a provided set of criteria and constraints. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Identify the different types of water filtration. Identify different types of water pollution. Utilize the engineering process in order to identify key features of a mechanical filtration system.	What types of water filters there are and what each is used for. The types of water pollution.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**ITEEA: Standards for Technological Literacy 15M**. Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. For instance, terraces, used in gardens or on farmland, prevent erosion by shortening the long slope of land into a series of shorter, more level steps. This

			allows heavy rains to soak into the soil rather than running off and causing erosion. **ITEEA: Standards for Technological Literacy 15N**. The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. For example, wise water use for gardens or farmland involves considering plant needs and efficient watering methods before installing, using, and maintaining irrigation systems. Management of agriculture requires considering such topics as the amount, orientation, and distribution of crops and other plants, the effects of pests, and the management of land and animals to prevent fire or drought. For example, pest management involves managing agricultural infestations (including weeds, insects, and diseases) to reduce adverse effects on plant growth, crop production, and environmental resources.
Design, Build, and Test their own mechanical filter. Identify the characteristics of a sediment filter.	How to create a basic water filtration system.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.C.7** Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.

Unit 7 Overview

Unit Title: Introduction to 3D Modeling

Unit Summary:
In this unit, students will be given a brief introduction into 3D modeling software. This software will be required for the final course unit, prosthetics design. Students will learn the basic features and procedures required for them to design their prosthetic device on the computers so that we can 3D print the devices for testing.

Suggested Pacing: 3-4 Lessons

Learning Targets

Unit Essential Questions:
- What is the purpose of 3D modeling software?
- What are the basic features of our 3D modeling software?
- How can I ensure accurate measurements of the software?
- How can the following basic procedures ensure I am drawing the parts of my device correctly?

Unit Enduring Understandings:
- 3D modeling software is designed to help users convert 2D sketches into functional parts.
- The basic features of 3D modeling software will allow us to draw the majority of our device.
- Measuring and planning are imperative to a successful model.
- Following basic procedures help improve drawing efficiency.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of tutorials.

Summative Assessments: Students will be assessed by their ability to accurately measure and digitally recreate 4 given objects. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Use 3D modeling software to draw simple and complex shapes. Use the basic features of the 3D modeling software. Take accurate measurements using an assortment of measuring tools.	How to use 3D modeling software to create different parts. How to measure to .001" accuracy. How to export their parts to be 3D printed. How to create 2D representations of their 3D parts.	Students will be assessed based upon their participation and completion of the different tutorials.	**HS-ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. **ITEEA: Standards for Technological Literacy 12 P:** Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. Many resources, such as library books, the Internet, word processing and spreadsheet software, in addition to computer-aided design (CAD) software, can be used to access information.

Unit 8 Overview

Unit Title: Prosthetics Design & Fabrication

Unit Summary:
In this unit, students learn about the history of prosthetics and how modern prosthetics function. They will also design and build a custom prosthetic device for a simulated user. Students will use the 3D modeling software from the previous unit to create their prosthetic device and then create it using the 3D printers.

Suggested Pacing: 14-16 Lessons

Learning Targets

Unit Essential Questions:

- What is the purpose of a prosthetic device?
- When did prosthetics first show up in history?
- How has technology impacted the design and functionality of prosthetic devices?
- What resources can we use to design our own prosthetic device?
- What are some important factors to consider when designing your prosthetics?

Unit Enduring Understandings:

- Prosthetics devices have been around for hundreds of years.
- Technology has greatly improved the functionality of prosthetics.
- Prosthetic devices can be very simple or very complex depending on the use.
- The majority of prosthetics are custom made to fit the user.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed based on their ability to design and create a prosthetic device for the given set of criteria and constraints. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Understand the history of prosthetic devices. Identify the different types of prosthetic devices. Understand the impact of new and emerging technologies on prosthetics design and fabrication.	The historical significance of prosthetics. The different types of prosthetics devices. How new manufacturing techniques and material science have accelerated the advancement of prosthetics design.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.B.4** Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants. **8.2.12.C.7** Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process

			through drawings that include data and materials.
Design, fabricate, and test a custom prosthetic device. Use 3D modeling software to create the individual parts of their prosthetic device.	How to design a simple prosthetic device.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**HS-ETS1-3** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **CRP11.** Use technology to enhance productivity.