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Fundamentals of Engineering and Design

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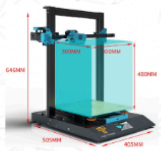
Introduction/Problem

- Teaching students practical problem-solving skills with real-world applications in their community.
- Naco Technical High School's goal to equip students with transferable skills for their future careers and/or employment opportunities.

Stakeholders

- Students and Teaching staff at Naco Technical High School
- Tom Carlson (NWI)



Solution

- Create a sustainable curriculum at Naco Tech High School that incorporates 3D printing and computer-aided design (CAD) as tools, utilizing TinkerCAD software with the end goal of having a showcase for the students to present their solutions to a problem they found in their community.
- Provide resources and support to ensure the continued success and sustainability of the curriculum, benefiting students for years to come.
- Provide training, and conduct meeting with teachers on how to effectively deliver the course.
- Supply 3D printers and laptops for CAD modeling and printing to ensure access to necessary hardware resources.

Accomplishments/Progress

- Conducted research on syllabuses and developed a comprehensive curriculum integrating 3D printing and CAD.
- Presented project concept for midterm and received positive feedback.
- Refine syllabus in discussions with Naco Tech High School, resulting in curriculum renaming to "Fundamentals of Engineering and Design".
- Made significant progress in developing course materials and instructional resources.
- Secured necessary resources, including 3D printers and laptops.

Impact

- Provides students with practical problem-solving skills that can be directly applied to real-world community needs.
- Equips students with transferable skills for future careers or employment opportunities.
- Enhances students' creativity, critical thinking, and design skills through hands-on learning with 3D printing and CAD.
- Fosters interest and engagement in engineering, design, and related fields among students.

Conclusion/Future Steps

- Collaborate with teachers and mentors for ongoing curriculum assessment and improvement.
- Explore opportunities to expand the curriculum.
- Consider integrating additional tools or technologies into the curriculum to broaden students' skillsets.
- Monitor the impact on students' academic performance, career readiness, and overall success.

Fundamentals of Engineering and Design

Fall semester syllabus

Week	Topic	Learning Objectives	Lessons/Assessments	Activities
1	Intro I	The WHY of 3D printing & Impact	**Lesson 1:** Introduction to 3D Printing - Introduction to the history and basic principles of 3D printing - Explanation of the different types of 3D printing technologies - Demonstration of 3D printing process (short video)	**Class discussion:** How has 3D printing impacted different industries? **Homework:** Research and write a short paper on the history of 3D printing
			Lesson 2: The Impact of 3D Printing - Introduction to the impact of 3D printing on society and the economy - Discussion of potential future applications of 3D printing - Overview of 3D printing as a problem-solving tool	**Group activity:** Brainstorm and present a list of ways 3D printing can be used to address societal issues **Classwork:** Create a TinkerCAD model of a problem in your community and brainstorm ways 3D printing can be used to solve it **Assessment:** Class participation and engagement during group activity **Homework:** Write a short reflection on the impact of 3D printing on society and the economy
2	Intro II	Teamwork & Human-Centered Design Principles (?) Engineering Design Process (?)	**Lesson 1:** Lecture on human-centered design principles and how to use them to create 3D designs	**Activity:** - Divide students into teams and assign them a design challenge to work on throughout the week - Have students conduct research on existing 3D designs that incorporate human-centered design principles and present their findings in class - Assign a reading on the engineering design process

			Lesson 2: Hands-on activity where students work in teams to brainstorm ideas and create a design using the engineering design process **emphasis on the importance of not worrying too much throughout this class about projects failing or not finishing in the time frame. They'll get better and these projects are to help them develop design instincts	and have students write a reflection on how they can apply this process to their design challenge - Have students create a rough sketch of their team's design and present it to the class for feedback
3	Intro III	- Understand the basics of 3D modeling using TinkerCAD - Learn how to create basic shapes and modify them in TinkerCAD - Apply problem-solving skills to complete a design challenge using TinkerCAD	**Lesson 1:** TinkerCAD Basics - Introduction to TinkerCAD interface and tools - Creating and manipulating basic shapes in TinkerCAD - Saving and exporting designs	**In-class activity:** Students will create a simple design in TinkerCAD (e.g. keychain, name tag) and export it for 3D printing **Homework**: Students will submit a reflection on their design process and what they learned about 3D modeling and problem-solving
			Lesson 2: Design Challenge - Introduction to problem-solving and design thinking - Explanation of design challenge prompt (e.g. design a functional tool for a specific task) - Brainstorming and ideation session	**In-class activity:** Students will work in groups to develop a design for the challenge using TinkerCAD, incorporating principles learned in Lesson 1 **Homework:** Complete a short quiz on the TinkerCAD interface and tools
4	Drafting I (Engineering Graphics)	Orthographic Projection Pt. 1 - Glass Box & Standard Views - Line Rules - Creating Projections	**Lesson 1**: - Introduction to orthographic projection and glass box method - Explanation of standard views and line rules - Practice exercise: Create projections of simple objects on paper	**Assessments:** - In-class assessment of students' understanding of orthographic projection, standard views, line rules, and creating projections **Activities:** - Hand-drafting of objects in the class, with a focus on accuracy and attention to detail - Homework exercises to practice creating projections

			Lesson 2: - Advanced exercises in creating projections with multiple objects - Introduction to section views and auxiliary views - Practice exercise: Create projections of more complex objects	on paper
5	Drafting II	Orthographic Projection Pt. 2 - Creating projections - Auxiliary views - Isometric - View Alignment	**Lesson 1:** - Review of orthographic projection principles from Week 4 - Introduction to auxiliary views and their applications - Practice creating auxiliary views from primary views on paper	**Assessment:** In-class exercise where students create auxiliary views of given primary views **Activities:** - Drawing exercises where students practice creating projections from primary views and creating auxiliary views - A group project where students collaborate to create a technical drawing of a machine or device, with each student responsible for a particular part or section of the drawing
			Lesson 2: - Introduction to isometric views and their applications - Practice drawing isometric views on paper - Introduction to view alignment and its importance in engineering graphics	**Assessment**: Homework assignment where students draw multiple isometric views of a given object and ensure that the views are properly aligned **Activities:** Peer review and critique sessions, where students evaluate each other's technical drawings and provide feedback for improvement.

6	Drafting III	Dimensioning Pt. 1 - Manufacturing needs - Impact of dimensioning - Appearance / Technique	**Lesson 1:** **-** Introduction to dimensioning and its importance in manufacturing - Overview of dimensioning tools and techniques	**Assessments:** - Dimensioning exercise in which students are given a part drawing with no dimensions and must add appropriate dimensions **Activities**: - Hands-on exercise: Practice dimensioning a simple object using basic dimensioning techniques
			Lesson 2: - Understanding the impact of dimensioning on design and manufacturing processes (15 minutes) - Overview of advanced dimensioning techniques, including tolerances and geometric dimensioning and tolerancing (30 minutes)	**Assessments:** - Short quiz on basic and advanced dimensioning techniques **Activities:** - Group discussion and collaboration to evaluate the effectiveness of different dimensioning techniques and how they affect the overall manufacturing process. - Hands-on exercise: Practice advanced dimensioning techniques on a more complex object (30 minutes)
7	Drafting IV	Dimensioning Pt. 2 - Locating Features & Choice - Understand the purpose and importance of locating features in technical drawings - Learn how to use basic dimensioning techniques to locate features on a technical drawing - Understand the importance of selecting appropriate dimensioning techniques	**Lesson 1:** Locating Features - Introduction to locating features and its importance in drafting - Types of features: size, shape, orientation, location, and runout - Techniques for specifying features: direct, indirect, and geometric dimensioning	**Assessments:** - Multiple-choice questions on the types and techniques of locating features - Hands-on activity: Students will practice locating features on a drawing using different techniques and dimensioning methods.

		based on the features being located	**Lesson 2:** Choice in Dimensioning - Introduction to choosing the appropriate dimensioning method for a given scenario - Factors that affect dimensioning choices: part function, manufacturing process, assembly, inspection, and cost - Examples of dimensioning methods and their advantages and disadvantages: coordinate, chain, and baseline dimensioning	**Assessments:** - Students will be given a drawing and asked to dimension it using the appropriate method and justify their choice. The exercise will be graded based on accuracy and justification. - Hands-on activity: Students will apply their knowledge of dimensioning choices to a drawing and justify their choice of dimensioning method.
8	Drafting V	Practice (?) - Application of past lessons	**Lesson 1:** - Review of previous lessons on drafting and dimensioning - Discussion of real-life applications of drafting and dimensioning in various industries - Instructor-led practice exercise on drafting and dimensioning	**Assessment 1:** - Quiz on the concepts covered in the previous weeks' lessons **Activity 1:** - Students will work on a group project where they are given a simple object and they will have to create a detailed engineering drawing with dimensions.
			Lesson 2: - Introduction to basic 3D modeling concepts - Discussion of how 3D modeling can be used in various industries - Hands-on practice with TinkerCAD	**Assessment 2:** - Instructor will review and provide feedback on the students' engineering drawings from the previous class **Activity 2:** - Students will continue working on their group project from the previous class, but this time they will create a 3D model of their object using TinkerCAD.
9	Ad-hoc Drafting Project	Group Project - draft a model of a solution to a classroom problem	**Lesson 1:** -Project description and goals -Initial brainstorming session	Group Activity -Students will draft and explain their drawings to the class
			Lesson 2	

			-Create unique solutions to force students to collaborate and explain their thought process	
10	Prototyping I	Understanding the prototyping process and creating initial prototypes using classroom items	**Lesson 1:** - Introduction to prototyping and its importance in the product design process	- Students will work in groups to brainstorm potential product designs and create initial sketches of their ideas - Students will work on hands on materials to create their own basic designs
			Lesson 2: - Students will be required to demonstrate their understanding of initial engineering concepts	
11	Prototyping II	Foundations of Design	**Lesson 1:** - Geometric Fundamentals - Strength of Shapes and Formations	Activity: - Nets and creating 3D shapes from the net
			Lesson 2: - Introduction to useful tools (ex. Purpose of a hammer, tape/adhesive) - Effects of friction	Activity: - Strength testing of certain composite shapes (shapes and adhesives) - Friction test/demonstration
12	Prototyping III	Design challenge (ex. Paper Bridges, Paper Towers)	**Lesson 1:** - Brainstorming - Team Time	Activity: - Design Challenge Team Time for creation, testing, and prepping presentation
			Lesson 2: -Brainstorming -Team Time (Developing presentation)	
13	Prototyping IV	Presentation	**Lesson 1:** - Testing	Activity: - Tests and final construction
			Lesson 2: - Final Presentation	Activity: - presentation and competition
14	Group Project I	Given simple materials and a ping pong ball, ask the	**Team Time**	Project Description and Goals Team Time

	(Design Challenge-Ping Pong)	students to construct something that will allow the ping pong ball to go from the top of the table to the floor in ten seconds		
15	Group Project II	Project Team Time	Team Time - testing and revising	Presentation description & requirements
16	Final Project	Proven Concept	Class Presentations	Presentations
			Class Competition	Competition

Spring-Block II

Week	Topic	Learning Objectives	Lessons/Assessments	Activities
1	Equipment 101	Understand the components of a 3D printer	**Lesson 1:** -Breakdown of each part of the printer and explain its use	**Activity:** - Explain parts of printer physically and watch part of the printing process
			Lesson 2: - Description of effects of filament type, printing size, unstable objects/shapes, and margin for error in printing	**Activity:** - Demonstrate lesson principles with a test printout to show differences in setting, size, etc.
2	Review I	- Review Drafting Principles	**Lesson 1:** - Review Drafting I - III	**Activity**: - Review worksheets, pop quiz, etc.
			Lesson 2: - Review Drafting IV - V	
3	Review II	- Review Prototyping Principles	**Lesson 1:** - Review Prototyping I - II	**Activity**: - Overview of material and geometric properties
			Lesson 2: - Quick Individual In-class Design Challenge	**Activity**: - Given a cup and random materials, construct a cup that will always land rightside up.
4	T. Modeling I	Understand TinkerCAD interface	**Lesson 1:** Introduction to TinkerCAD Interface - Introduction to TinkerCAD interface - Navigation of the 3D space - Basic shapes and their properties - Creating simple designs using shapes	**Activity 1:** Create a Simple Design - Students will create a simple 3D design using basic shapes in TinkerCAD - The design could be a basic object such as a cup or a box **Assessment 1:** Quiz on TinkerCAD Interface

				- Students will take a quiz to test their knowledge on the TinkerCAD interface and basic shapes
			Lesson 2: Advanced TinkerCAD Tools - Introduction to advanced TinkerCAD tools such as workplane, mirror, align, group, and ungroup - Using advanced tools to create more complex designs	**Activity 2:** Create a More Complex Design - Students will create a more complex 3D design using advanced TinkerCAD tools - The design could be a more complex object such as a car or a building **Assessment 2:** Design Review - Students will present their more complex 3D design and receive feedback from their peers and the instructor
5	T. Modeling II	Creating Basic Shapes and Combining Them	**Lesson 1:** Advanced TinkerCAD Tools - Learn how to use advanced TinkerCAD tools to create more complex designs - Overview of advanced tools such as shape generators, pattern generators, and import/export functions	**Activity 1:** - Guided practice in using advanced tools to create complex designs **Assessment:** - Review of completed designs and feedback on use of advanced tools
			Lesson 2: Practice Time - Learning Objective: Practice using TinkerCAD to create designs independently	**Activity 1:** - Independent design project with guidance and feedback from the instructor **Assessment:** - Review of completed designs and feedback on use of TinkerCAD tools and techniques

6	T. Modeling III	Creating 3D Models with TinkerCAD	**Lesson 1:** - Review of previous TinkerCAD lessons - Introduction to 3D modeling concepts such as extrusion and rotation - Demonstration of basic 3D models	**Assessments:** - Assessment of student understanding of TinkerCAD interface and concepts - Evaluation of student's 3D models
			Lesson 2: - Hands-on activity using TinkerCAD to create a simple 3D model - Students will be able to apply the concepts learned in Lesson 1 to create their own 3D models - Peer review and critique of 3D models	**Activities:** - Guided practice on TinkerCAD - Independent practice on TinkerCAD to create 3D models - Peer review and critique of 3D models
7	Group Project I (Rube Goldberg Machine)	Create a multipart project that accomplishes a normal task	**Lesson 1:** - Project Description and Team Time *quick design challenge	Team Time
			Lesson 2: - Team Time and final demonstrations of project accomplishing goal	Team Time and Demonstrations
8	T. Modeling IV	Apply 3D Modeling Concepts to Real-world Problems	**Lesson 1:** Understanding Real-world Applications of 3D Printing - Introduction to real-world applications of 3D printing - Discussion of how 3D modeling can be used to solve real-world problems	**Activity:** - Brainstorm a list of real-world problems that can be solved using 3D modeling, and pick one problem to work on for the rest of the week

			Lesson 2: Design and Prototype Solution to Real-world Problem - Introduction to the design thinking process - Work on designing and prototyping a solution to the real-world problem identified in Lesson 1	**Activity:** - Use TinkerCAD to create a 3D model of the solution designed in Lesson 2 and create a physical prototype of the solution using the 3D printer.
9	T. Modeling V	Advanced Tools in TinkerCAD	**Lesson 1:** Advanced Tools in TinkerCAD - Overview of advanced tools in TinkerCAD - Use of advanced tools in designing models - Demonstration of how to use advanced tools to create complex models	**Activities:** - Students will follow along with the instructor to learn how to use advanced tools in TinkerCAD - Students will create a complex model using advanced tools
			Lesson 2: Designing for 3D Printing - Best practices for designing models for 3D printing - Importance of designing for the intended purpose of the model - Understanding the limitations of 3D printing technology	**Activities:** - Students will design a model with the intention of 3D printing it - Students will learn how to troubleshoot common 3D printing problems and optimize their model for printing **Assessment:** - Students will be assessed on their ability to use advanced tools in TinkerCAD to create a complex model - Students will be assessed on their understanding of best practices for designing models for 3D printing and their ability to optimize their model for printing.

10	Group Project II (Design Challenge - Find and Fix the Error)	Introduce an existing solution for a problem that is not working. Encourage the students to find creative ways to modify the existing solution and fix it	**Lesson 1:** - Project Description - Team Time to Brainstorm and Analyze the given problem **Lesson 2:** - Team Time	Team Time
11	Group Project II	Finish project *Emphasis on the importance of checking for errors and going through this process several times in the Design Process	Team Time Presentations - how they identified the error and what they did to fix it	Team Time Presentation and Feedback
12	Looking Ahead	To help students reflect on the skills they have learned and explore potential future applications of those skills in their lives and community.	**Lesson 1:** Reflection - Students will reflect on the skills they have learned throughout the course. - Students will write a brief reflection on how they have applied these skills in their lives and community. **Lesson 2:** Exploring Future Applications - Students will brainstorm potential future applications of the skills they have learned. - Students will research potential career paths or college majors that would utilize the skills they have learned. - Students will discuss and share their findings with the class.	**Activities:** - Reflection writing exercise - Small group brainstorming session on potential future applications - Individual research on potential careers or college majors - Group discussion and sharing of research findings.
13	Design Challenge - Draft/	Unproven Idea (Create something that will better learning experience in	Project Description and Brainstorm Draft	Team Time

	Brainstorm	classroom)		
14	Design Challenge - 3D Prototype		3D Prototype construction	Team Time
			Testing and Revising	
15	Design Challenge - Tinkercad & Test		Tinkercad Modeling	Team Time
			Testing and Revising	
16	Design Challenge - Present Solution		Compiling all parts and final checks	Team Time
			Presentations	Presentations

Materials and Equipment Cost					
Item	**Description**	**Quantity Needed**	**Cost per Item**	**Total Cost**	**URL Link**
FLASHFORGE 3D Printer Adventurer 3 Pro with 2 Removable Nozzle, Glass Bed and Leveling-Free, Fully Assembled, High Precision Printing with PLA/ABS/PETG/PLA-CF/PETG-CF	-【240℃ & 265℃ Nozzle Bundle】printer equipped with a 0.4mm 240℃ nozzle and a 0.4mm 265℃ nozzle. Heat to 200°C (392°F) within 60 seconds. Detachable design allows you to remove the nozzle from the extruder in one push. -【Leveling Free & Glass Bed】Out of the box, Build plate is well leveled in the factory. Better flatness than flexible build plate, greatly minimal warping issues.Compatible with pre-released PEI platform assembly. -【HD Camera & Support Various Filament】Built-in HD Camera allows you to remotely view the printing process online. Adventurer 3 Pro shows great performance on 3d printing ABS, PLA, PC, PETG, PLA-CF, PETG-CF, and other filaments. -【Filament Auto-Loading & Mute Printing】Enclosed spool holder, put filament end in, then trigger filament loading via the touchscreen for auto & smooth feeding. <45dB, ensures you a quiet and comfortable printing environment. -【Efficient After-sales Support】All of our 3d printers provide one month free return and exchange. Lifetime technical support, a one-year warranty and reliable 12-hour response service. At Flashforge, zero risk purchase is for every customer's smiles.	2	$399.00	$798.00	URL Link Link for additional information about this product

Flashforge ABS Pro 1.75mm, 3D Printer Filament 1kg (2.2lbs) Spool-Dimensional Accuracy +/- 0.02mm, Great for Printing Heat Resistant Functional Parts (Green, ABS Pro)	- [High Durable & Temperature Resistance】---Flashforge ABS Pro is an improved ABS 3D printing filament. Compared with normal ABS filament, it has lower shrinkage, less odor, milder printing conditions. Great for creating durable items that require a higher resistance to heat. ABS Pro can be used for full functional models, such as sport camera mounts, tools, electric equipment enclosures etc.And is the closest material to real production models. - High Quality Raw Material】---Flashforge 3D filaments are loved by the printing community for their high-quality composition. Environmental-friendly, bright colors and compatibility in mind. Flashforge ABS Pro filament undergoes numerous testing procedures to ensure that you spend less time troubleshooting and effort every time you print. -【Clog-Free, Bubble-Free & Easy-to-use】--- Designed and Manufactured with Clog-Free patent to guarantee a smoother and more stable printing experience with Flashforge 3d printer filaments. Complete drying for 24 hours before packaging and vacuum sealed with desiccants in a transparent bag, no bubble and easy to print. Full mechanical winding and strict manual examination, to make sure the line tidy and less-tangle, so as to avoid possible line breaking. -【Dimensional Accuracy & Consistency】--- Advanced CCD diameter measuring and self-adaptive control system in the manufacturing guarantee these ABS Pro filaments to be strict tolerances, diameter 1.75mm, dimensional Accuracy 99% Probability +/- 0.02 mm without any exaggeration; 1 kg spool (2.2lbs) -【Risk-Free】--- One-month free trial, 30 day Money-back if you’re not satisfied. At Flashforge, zero risk purchase is for every customer's smiles.	10	$21.99	$219.90	URL Link

ASUS 2022 Vivobook Go 11.6" Ultra-Thin Light Business Student Laptop Computer, Intel Celeron N4020 Processor, 12Hours Battery, Win11S+1 Year Office 365 Personal, Black (192GB Storage)	-【Processor】Dual Core Intel Celeron N4020 , 2.80GHz Brust Frequency, 6W TDP, 4MB Cache, Featuring true machine intelligence and a newly designed efficient architecture, the groundbreaking processor learns and adapts to your needs so you can achieve more -【Display】11.6" HD (1366 x 768) Display with NanoEdge and up to 178 degree viewing angles, narrow bezel design, enables you to focus more on your work and studies -【Memory & Storage】4GB High-Bandwidth DDR4 Memory, 192GB Storage, Smoothly run multiple applications and browser tabs at the same time, ensure the smoothness of daily use and improve your work efficiency -【Operating System】 Windows 11S (Easy Switch to Windows 11 Home) | 12Hrs+ Battery Life | One Year of Office 365 Personal -【Included in the package】Bundled with Microfiber Cloth	2	$229.99	$459.98	URL Link
			Total Budget Needed:	$1477.88	