



Applied Technology
Grade12
Computer Aided Design IV
6/3/2022
Patrick Slater/Alina Duran

Wayne School District

Curriculum Format

Content Area/ Grade Level/ Course:	Applied Technology Grade 12 Computer Aided Design IV
Unit Plan Title:	Unit 1 Prototyping
Time Frame	Twelve weeks
Anchor Standards/Domain* *i.e: ELA: reading, writing i.e.: Math: Number and Operations in Base 10	
<p>8.2 Design Thinking This standard, previously standard 8.2 Technology Education of the 2014 NJSL – Technology, outlines the technological design concepts and skills essential for technological and engineering literacy. The new framework design, detailed previously, includes Engineering Design, Ethics and Culture, and the Effects of Technology on the Natural world among the disciplinary concepts</p> <p>9.2 Career Awareness, Exploration, Preparation and Training. This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.</p> <p>Standard 9.4 Life Literacies and Key Skills. This standard outline key literacies and technical skills such as critical thinking, global and cultural awareness, and technology literacy* that are critical for students to develop to live and work in an interconnected global economy.</p> <p>Anchor Companion Standards (Reading and Writing Grades 11-12)</p>	
Unit Overview	

CAD technologies allow designers to create virtual replicas of real world objects. Virtual prototyping is a strategy employed by designers to study a digital model of a proposed product in depth before committing the time, labor, and expense necessary to fabricate a physical prototype. The strength of virtual prototyping lies in the designer's ability to rapidly manipulate aspects of the model to create, study, and compare multiple design iterations.

This unit introduces students to advanced modeling and modification techniques for rapid variation. They use collections of formulas to drive model parameters, create multiple design configurations, and explore advanced BIM editing techniques. They learn how to use a variety of technologies to most appropriately develop specific aspects of a complex prototype. Having leveraged the power of the computer to create virtual mock-ups, they use digital fabrication tools to create physical prototypes.

Standard Number(s) * i.e: Math: 3.NBT.1 i.e.: RL 8.1

[Progress Indicators- Reading and Writing Standards Grades 9-10](#)

[Progress Indicators- Reading and Writing Grades 11-12](#)

8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.

8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.

8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.

8.2.12.NT.2: Redesign an existing product to improve form or function.

9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs. • 9.2.12.CAP.3: Investigate how continuing education contributes to one's career and personal growth.

9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a

9.4.12.CI.2: Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8).

9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Intended Outcomes - {Essential Questions}

- Explain the relationship between spreadsheets and building models.

- How can I manage a design with variables?
- Explain the relationship between mass production and engineering tolerance.
- Define engineering fit.
- How do we typically build relationships among components in scripting editors?
- Can we write programs to automate design tasks?
- In which situations is it most appropriate to use certain modeling and fabrication tools?
- Are there circumstances in which buildings change significantly?
- Do designers ever make proposals before they are apprised of all the project constraints?

Enduring Understandings

- We can use spreadsheets or text editors to organize and edit model data.
- We can use equations and relationships to drive model parameters.
- No two mass produced parts are identical. Tolerance allows us to specify allowed variation.
- Engineering fit is the degree of tightness or looseness between mated parts.
- Technical references can provide us with a blueprint for defining parametric relationships in our models.
- We have an arsenal of tools that we can use for specific tasks in multi faceted projects.
- We should consider the materials and fabrication tools at our disposal as we design our models.
- Building models can help us manage a building's life cycle. This can save money and conserve resources.
- Design options allow us to visualize and experiment with multiple project variations.

In this unit plan, the following 21st Century themes and skills are addressed.

<i>Check all that apply.</i> 21st Century Themes		<i>Indicate whether these skills are E-Encouraged, T-Taught, or A-Assessed in this unit by marking E, T, A on the line before the appropriate skill.</i> 21st Century Skills	
X	Global Awareness	A	Creativity and Innovation
X	Environmental Literacy	A	Critical Thinking and Problem Solving
X	Health Literacy	A	Communication
X	Civic Literacy	A	Collaboration
X	Financial, Economic, Business, and Entrepreneurial Literacy		

Student Learning Targets/Objectives (Students will know/Students will understand)

Students will:

- Use an external reference to edit parametric models.
- Define equations to automate modifications.
- Model and fabricate mating parts designed for engineering fit.
- Use configurations to generate and modify virtual models.
- Use BIM conceptual massing tools.
- Implement design variation techniques in a Building Information Model.

- Use a 3D printer for fabrication.
- Plan to use a third party service for fabrication.
- Use a laser cutter for fabrication.

Assessments (Pre, Formative, Summative, Other)

*Denote required common assessments with an **

- **Pre-assessments**
 - Diagnostic tasks
 - Anticipatory sets
- **Formative assessments**
 - Group discussion
 - Individual conference
 - Verify understanding during guided activities
 - Peer assessment
 - Self assessment
 - Reflection and goal-setting
- **Summative assessments**
 - Quizzes
 - Performance tasks

Teaching and Learning Activities

Activities

Unit overview

- Prototyping: Concept
- Prototyping: Virtual
- Prototyping: Physical

Equations

- Driving parameters
- Composing and evaluating equations
- Parametric equations

Fabricating joints

- Tolerance
- Engineering fit
- Sliding and revolute joints

Fabricating fasteners and gears

- Technical references
- Gear generator
- Screw threading

Algorithmic modeling: Case studies

- Engineering Design
- Industrial Design
- Architectural design

BIM mass modeling

- Conceptual Modeling Environment
- Generating building elements from conceptual mass
- Third party interoperability

BIM design variation

- Phasing

	<ul style="list-style-type: none"> ● Groups ● Design options <p>3D Printing</p> <ul style="list-style-type: none"> ● Modeling for efficiency ● Speed, quality, adherence ● Safety, operation, and maintenance <p>Laser cutting</p> <ul style="list-style-type: none"> ● Modeling for efficiency ● Vector software ● Safety and operation <p>Outsourcing fabrication</p> <ul style="list-style-type: none"> ● Survey of devices and services ● Guidelines for engineering fit ● Estimating and minimizing costs
<i>Differentiation Strategies</i>	<p>Tiered performance tasks:</p> <ul style="list-style-type: none"> ○ Capstone: <ul style="list-style-type: none"> ● Students create virtual prototypes and design their models for rapid iteration. They use digital fabrication technologies to create physical models of their prototypes. ○ Extension: <ul style="list-style-type: none"> ● Students may explore interoperability among these tools. For instance: Students may use surface modeling tools to create the shell for a mechanism designed in a engineering modeling environment. ○ Accommodation: <ul style="list-style-type: none"> ● Instead of designing a model from scratch, use prebuilt algorithms and edit their parameters to create a desired part..
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Resources

- CAD workstation/software
- BYOD resources
- Internet
- Google Classroom
- Projection system
- Student monitoring system
- Reference materials
- Readings and problem sets
- Digital fabrication hardware/proprietary software/consumables

Curriculum Format

Content Area/ Grade Level/ Course:	Applied Technology Grade 12 Computer Aided Design IV
Unit Plan Title:	Unit 2 Polygon Modeling
Time Frame	Twelve weeks

Anchor Standards/Domain* *i.e: ELA: reading, writing i.e.: Math: Number and Operations in Base 10

8.2 Design Thinking This standard, previously standard 8.2 Technology Education of the 2014 NJSLS – Technology, outlines the technological design concepts and skills essential for technological and engineering literacy. The new framework design, detailed previously, includes Engineering Design, Ethics and Culture, and the Effects of Technology on the Natural world among the disciplinary concepts

9.2 Career Awareness, Exploration, Preparation and Training. This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.

Standard 9.4 Life Literacies and Key Skills. This standard outline key literacies and technical skills such as critical thinking, global and cultural awareness, and technology literacy* that are critical for students to develop to live and work in an interconnected global economy.

[Anchor Companion Standards \(Reading and Writing Grades 11-12\)](#)

Unit Overview

Polygonal modeling allows designers to create approximations of complex surfaces with polygon meshes. This technology is widely employed to create lightweight assets for interactive media. It is also ideal for producing illustrations and digitally fabricated objects that require surfaces with organic/sculptural qualities.

Students will learn how this technology is used by designers to produce digital and physical products. The class reviews mathematic concepts related to this technology. The unit capstone requires students to use this technology to create a model for illustration or rapid prototyping.

Standard Number(s) * i.e: Math: 3.NBT.1 i.e.: RL 8.1

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8.2.12.NT.2: Redesign an existing product to improve form or function.

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a)

9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12DA.5, 7.1.IH.IPRET.8)

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Intended Outcomes - {Essential Questions}

- What is a polygon mesh?
- Which disciplines make use of surface modeling technologies?
- Compare polygon modeling to solid modeling, BIM, and NURBS modeling.
- Define cusp, inflection, and tangent.
- How was the lofting technique originally employed?
- How does the density of a meshed surface affect its performance?
- How does the density of a meshed surface affect its appearance?
- How does the regularity of a meshed surface affect its quality?
- How can we efficiently edit dense meshed surfaces?

- What is interpolation?

Enduring Understandings

- Several properly juxtaposed planes can be used to simulate a smooth surface.
- Polygon modeling techniques are used to create digital assets, illustrations, physical products, and engineering simulations.
- A variety of tools – each with its own strengths and limitations – may be used in a design pipeline.
- Digital modeling functions are often based on mathematics concepts.
- Traditional fabrication techniques often serve as the inspiration for digital modeling tools.
- Assets made with fewer polygons allow the programs that use them to operate more efficiently.
- Denser polygon meshes are required to simulate areas of greater deformation.
- We can subdivide regular mesh topology with predictable results.
- It is possible to control large groups of polygons with relatively few controls.
- We can leverage the computer's computational strength to efficiently create and edit large data sets.

In this unit plan, the following 21st Century themes and skills are addressed.

<i>Check all that apply.</i> 21st Century Themes		<i>Indicate whether these skills are E-Encouraged, T-Taught, or A-Assessed in this unit by marking E, T, A on the line before the appropriate skill.</i> 21st Century Skills	
<input type="checkbox"/>	Global Awareness	<input type="checkbox"/> A	Creativity and Innovation
<input type="checkbox"/>	Environmental Literacy	<input type="checkbox"/> A	Critical Thinking and Problem Solving
<input type="checkbox"/>	Health Literacy	<input type="checkbox"/> A	Communication
<input type="checkbox"/>	Civic Literacy	<input type="checkbox"/> A	Collaboration
<input checked="" type="checkbox"/>	Financial, Economic, Business, and Entrepreneurial Literacy		

Student Learning Targets/Objectives (Students will know/Students will understand)

- Students will:**
- Compare surface modeling techniques.
 - Use layers and hierarchical lists to organize assets in complex virtual scenes.
 - Understand how to use interpolation to leverage the strengths of the computer for modeling.
 - Edit models by accessing and manipulating their construction history.
 - Predict and observe the results of editing the two-dimensional components of three-dimensional forms.
 - Optimize the relationships among geometric components of a polygon mesh.
 - Review the physics of light, and use basic CGI tools to simulate light and materiality.
 - Understand how polygon modeling technologies are used in various industries.
 - Use polygon modeling techniques to simulate surface conditions commonly encountered in industrial design.
 - Create three-dimensional models from multiple cross sections.
 - Use appropriate technologies in a design pipeline.
 - Apply the process of design to modeling tasks.

Assessments (Pre, Formative, Summative, Other) Denote required common assessments with an *

- **Pre-assessments**
 - Diagnostic tasks
 - Anticipatory sets
- **Formative assessments**
 - Group discussion
 - Individual conference
 - Verify understanding during guided activities
 - Peer assessment
 - Self-assessment
 - Reflection and goal-setting
- **Summative assessments**
 - Quiz
 - Performance task

Teaching and Learning Activities

Activities

Surface Modeling Systems

- Polygonal vs. NURBS
- Survey of applications
- Case studies

System overview

- UI
- Object properties / organization
- Transformations

Modeling with primitives

- Primitives and parameters
- Modifiers
- History editing

Box modeling

- Sub-object levels
- Edge rings and loops
- Smoothing

Material editor

- Material types
- Parameters
- Libraries

Quad modeling

- Poly-editing toolset
- Low-poly cage
- Sub-division surfacing

Mimicking industrial features

- Emboss and inset
- Panel gaps
- Holes

Surfacing theory and practice

- Sub-division
- Edge flow
- Topology management

Rendering primer

- Material palette

	<ul style="list-style-type: none"> ● Lighting setup ● Camera and rendering parameters <p>Interoperability</p> <ul style="list-style-type: none"> ● Import / export best practices ● Layer control ● External references <p>Modeling challenge</p> <ul style="list-style-type: none"> ● Virtual studio ● Research ● Model development
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<i>Differentiation Strategies</i>	<p>Tiered performance tasks:</p> <ul style="list-style-type: none"> ○ Capstone: <ul style="list-style-type: none"> ● Students use polygon modeling techniques to produce assets for an illustration or an interactive environment. ○ Extension: <ul style="list-style-type: none"> ● Students review criteria for digital fabrication. They modify their models to ensure that they meet the required standards. They print the models using the lab equipment or a cloud service. They compare fabricated mesh surfaces to NURBS surfaces. ○ Accommodation: <ul style="list-style-type: none"> ● Students and the teacher choose the techniques that the student will use to showcase their abilities. Students may work in teams with each team member taking responsibility for a different modeling technique.
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Resources	
<ul style="list-style-type: none"> • CAD workstation/software • BYOD resources • Internet • Google Classroom • Projection system • Student monitoring system • Reference materials • Readings and problem sets • Digital fabrication hardware/ proprietary software/consumables 	

Wayne School District
Curriculum Format

Content Area/ Grade Level/ Course:	Applied Technology Grade 12 Computer Aided Design IV
Unit Plan Title:	Unit 3 Computer Generated Imagery (CGI)
Time Frame	Twelve weeks
Anchor Standards/Domain* *i.e: ELA: reading, writing i.e.: Math: Number and Operations in Base 10	
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Unit Overview	

Computer Generated Imagery technologies leverage computational power to simulate light and materiality. CGI was used primarily by the entertainment industry to create movies, games, and special effects. It has since been adopted by engineers and architects for design visualization and presentation, and by illustrators and marketing professionals to produce promotional materials.

During this unit, we explore real-world lighting phenomena and investigate how computers are used to simulate them. Students use local and cloud-based platforms to produce lighting simulations of objects and spaces that they have modeled in the class to date. The resulting images are used to augment the students' portfolios.

Standard Number(s) * i.e: Math: 3.NBT.1 i.e.: RL 8.1

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Intended Outcomes - {Essential Questions}

- List the sources of illumination for our classroom. Describe the path that light takes from the source to your eye.

- Draw a graph that compares various methods to simulate the decay of light in terms of computational expense and realistic results.
- What is a material editor? How do CGI systems simulate texture?
- Describe how the Sun’s position in the sky changes during the course of a day or year.
- How does doubling the dimensions of an image affect the time it takes to render it? What is a render farm?
- Compare raster and vector images. How are images compressed? Compare jpeg, tiff, and gif file types.
- What is a pixel? What does it mean to create resolution? Is such a thing possible?
- Compare diffuse, ambient, and specular parameters. Look up and apply the IOR for water, glass, and diamond.
- How would you simulate the texture of an orange peel?
- Describe how a team of animators would produce a cartoon fifty years ago. What is a key frame? What are the respective roles of a human and the computer when producing a digital animation?

Enduring Understandings

- Observation is an important technique for the study of physical phenomena.
- We can simulate real world phenomena with computational techniques that are relatively inexpensive.
- We can simulate material properties such as color, reflection, refraction, and texture.
- Time of day, time of year, and location on Earth affect the relative position of the Sun in the sky.
- Dividing computationally expensive tasks among several computers can save a significant amount of time.
- Vector image quality does not decay with enlargement. Rasterized image quality does.
- Increasing resolution yields negative results. Raster data should be captured at the highest reasonable resolution.
- Vector images are edited by manipulating geometry. Raster images are edited by manipulating groups of pixels.
- CGI techniques can be used as an alternative to modeling to simulate texture and other geometric features.
- A key frame is a significant moment in an animated sequence. ‘In-between’ frames are interpolated between key frames.

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<input type="checkbox"/>	Global Awareness	A	Creativity and Innovation
X	Environmental Literacy	A	Critical Thinking and Problem Solving
<input type="checkbox"/>	Health Literacy	A	Communication

X

Civic Literacy
Financial, Economic, Business, and
Entrepreneurial Literacy

A

Collaboration

Student Learning Targets/Objectives (Students will know/Students will understand)

Students will:

- Survey professional applications of CGI technology.
- Compare the properties of physical lights to simulated lights in CGI environments.
- Simulate both natural and studio lighting conditions.
- Simulate material qualities (color, reflectivity, IOR).
- Understand best practices for handling raster images.
- Use image editing tools to modify raster images.
- Use procedural and texture maps to simulate surface geometry.
- Apply UV mapping theory to match two-dimensional images to three-dimensional geometry.
- Simulate camera operation.
- Understand the interpolation process. Define key frames and edit acceleration curves.
- Understand how to adjust render settings to maximize productivity.
- Understand the advantages of using cloud services to perform demanding computational tasks.

Assessments (Pre, Formative, Summative, Other) Denote required common assessments with an *

- **Pre-assessments**
 - Diagnostic tasks
 - Anticipatory sets
- **Formative assessments**
- Group discussion
 - Individual conference
 - Verify understanding during guided activities
 - Peer assessment
 - Self-assessment
 - Reflection and goal-setting
- **Summative assessments**
 - Quiz
 - Performance task

Teaching and Learning Activities

Activities

- Unit Overview**
- Materials and lighting
 - Animation
 - Rendering and editing
- Case studies**
- Solar simulation
 - Marketing materials
 - Entertainment industry
- Engine setup**

- Interface
- Scene setup
- Export/import best practices

Light theory

- Real world lighting
- CG lights
- Shadows

Lighting techniques

- Studio lighting
- Solar simulation
- Interiors

Material editor

- Libraries
- Procedural parameters
- Simulating texture

Bitmaps

- Raster vs. vector
- Resolution
- Creating content

Editing raster data

- Image editing GUI
- Selecting and manipulating pixels
- Layers and masks

Mapping

- UV coordinate theory
- UVW mapping
- Unwrapping

Cameras

- Creation methods
- Parameters
- Path following

Animation

- Framerate
- Key-framing and interpolation
- Acceleration curves

Rendering

- Engines
- Quality versus computational expense
- Effects

Differentiation Strategies

Tiered performance tasks:

○ Capstone:

- Students define material and lighting parameters for a building or object that they have previously modeled. They compare various materiality and lighting options. They produce draft renderings on the local machines and high quality renderings in the cloud.

○ Extension:

- Students use Google Cardboard to create panoramic renderings. They may animate a camera to produce a

	<p>predefined architectural walkthrough, or they may use a video game engine to produce an interactive walkthrough. They may use advanced rendering engines with more robust capabilities and compare final results.</p> <ul style="list-style-type: none">○ Accommodation:<ul style="list-style-type: none">● Students select a limited number of topics to focus on during the capstone project. For instance: They may produce an animated solar simulation, but utilizing a monolithic material scheme instead of defining a variety of materials.
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Resources	
<ul style="list-style-type: none">• CAD workstation/software• BYOD resources• Internet• Google Classroom• Projection system• Student monitoring system• Reference materials• Readings and problem sets	