BERKELEY HEIGHTS PUBLIC SCHOOLS
BERKELEY HEIGHTS, NEW JERSEY

COLUMBIA MIDDLE SCHOOL
PRACTICAL ARTS

3D MODELING AND DESIGN

Curriculum Guide

Date: September 2017
Updated: August 2022

Dr. Melissa Varley, Superintendent
Dr. David Greer, Assistant Superintendent
Mr. James Finley, District Supervisor
Mr. Drew Ziobro, District Supervisor

Developed by: Ernest Monaco

This curriculum may be modified through varying techniques,
strategies, and materials, as per an individual student's
Individualized Educational Plan (IEP)

VISION STATEMENT

STEM is the integrated approach to education in the areas of Science, Technology, Engineering, and Mathematics. Instruction is student centered and driven by an iterative design process, exploratory learning, problem-solving, and engagement in authentic contexts.

Through the process of engaging in authentic, hands-on, open-ended design challenges, students will become familiar with the steps and processes associated with successful problem solving in the context of the engineering design process. Students will gain proficiency in the application of relevant Math, Science, and Technology concepts while expanding their comprehension and understanding of the human-designed world, the nature of technology and engineered systems, and the skills, knowledge, and attitudes necessary to become well-rounded and successful twenty-first century problem solvers and innovators.

MISSION STATEMENT

3D Printing and Modeling is a one quarter cycle class designed for 7th and 8th grade students at Columbia Middle school. This course addresses 21st century skills and career ready practices. Students utilize the engineering design process, 3D modeling skills, and 3D fabrication methods in the design of real world objects. Throughout the course, students will be engaged in an authentic problem-based learning environment working as a team and serving in different engineering roles. Students will learn to utilize feedback from this process to revise their designs and develop better solutions.

COURSE PROFICIENCIES
COURSE OBJECTIVES

Modeling
- Creating of computer based 3D models
- Modification of 3D models

Fabrication
- History of Fabrication Methods
- Fabricate 3D models utilizing 3D printers.
- Using 3D printer settings to control model properties

The engineering design process is a loop because although the steps are listed in sequential order, you will likely return to previous steps multiple times throughout a project. It is often necessary to revisit stages or steps in order to improve that aspect of a project.

 In the engineering design process, engineers…
- Ask (What are we trying to solve?, What are the constraints?, What are the requirements?, What questions do you have about the challenge?)
- Imagine (What are the possible solutions?, Brainstorm ideas, list materials needed, explain the ideas, create a sketch for you ideas)
- Plan (Choose a final solution, sketch a final solution, decide the steps you will take to create your solution, create a technical drawing to explain your design)
- Create (follow your plan and create your design, what changes did you make while creating your design? Why?, Self reflection)
- Improve (What worked well? What could have gone better? What improvements could you make to allow your design to be more successful? Why is the redesign better than the original design?)

STUDENT PROFICIENCIES

Students will:
- Engage in questioning techniques
- Understand the importance of labeled sketches in engineering design
- Employ various brainstorming techniques
- Use orthographic drawings (multi-view drawings) to communicate design intent
- Engage in prototyping
- Utilize computer software packages to model real world objects
- Design and build complex models that interact with each other
- Utilize 3D printers to fabricate models
- Use tolerances in order to control model interaction
- Optimize 3D printer settings based on the model requirements

METHODS OF EVALUATION

1. Teacher observation/questioning/monitoring
2. Engineering Notebooks/Journals
3. Team evaluation rubrics
4. Self and peer evaluation
5. Performance tasks/assessments
6. Reports and presentations
7. Student created designs and models

MODIFICATIONS & ACCOMMODATIONS

Modifications and Accommodations for Special Education students, students with 504s, English Language Learners and Gifted and Talented students may include but are not limited to the following:

Special Education
- Individualized Education Plans (IEPs)
- Exemplars of varied performance levels
- Multimedia presentations
- Sheltered instruction
- Consultation with ESL teachers
- Manipulatives
- Tiered/Scaffolded Lessons
- Mnemonic devices
- Visual aids
- Modeling
- Guided note-taking
- Study Guides
- Modified homework
- Differentiated pre-typed class notes and example problems
- Use of the special education teacher to re-instruct in flexible small groups for the struggling learner
- Manipulatives
- Flipped Instruction
- Word banks
- Reduced choice on assessments
- Preferential seating
- Choice activities
- Modified time requirements
- Modified notes
- Modified lesson, assessment and study guide format
- Provide an enriched curriculum and activities
- Independent projects
- Contracts/behavior support plans
- Open-ended responses
- Project-based learning
- Group activities
- Guided Notes
- Functional learning incorporated into each lesson
- Exploration Activities
- Assessment read aloud
- Small group assessments

- Organizational Support
- Oral questioning assessments to supplement written response
- Pre-writing Structural Supports for extended writing tasks
- Ongoing teacher feedback as part of the writing process
- Interactive Study Guides
- Multi-sensory approach to instruction
- Written and spoken step-by-step directions
- Content-focused assessment (not grading for spelling/grammar)
- Graphic organizers
- Non-verbal cues to begin task/remain on task/refocus
- Individual monitoring for understanding/reinforced instruction
- Printed copies of class readings for application of Active Reading Strategies

Gifted & Talented
- Provide one-to-one teacher support
- Curriculum Compacting
- Advanced problems to extend the critical thinking skills of the advanced learner
- Supplemental reading material for independent study
- Elevated questioning techniques using Webb's Depth of Knowledge matrix
- Curriculum Compacting
- Flexible grouping
- Tiered assignments
- Topic selection by interest
- Manipulatives
- Tiered Lessons
- Flipped Instruction
- Multimedia Presentations
- Open-ended responses
- Project-based learning
- Group activities
- Guided Notes
- Conclusions and analysis of exploratory activities
- Career based learning incorporated into each lesson
- Exploration Activities
- Student choice

ELLs
- Exemplars of varied performance levels
- Multimedia presentations
- Sheltered instruction
- Consultation with ESL teachers
- Manipulatives
- Tiered/Scaffolded Lessons
- Mnemonic devices
- Visual aids

- Modeling
- Guided note-taking
- Study Guides
- Modified homework
- Differentiated pre-typed class notes and example problems
- Individualized instruction plans
- Manipulatives
- Flipped Instruction
- Words banks
- Reduced choice on assessments
- Preferential seating
- Choice activities
- Modified time requirements
- Modified notes
- Modify lesson, assessment and study guide format
- Provide an enriched curriculum and activities
- Contracts/management plans
- Open-ended responses
- Project-based learning
- Group activities
- Guided Notes
- Exploration Activities
- Assessment read aloud
- Small group assessments
- Oral questioning assessments to supplement written response
- Pre-writing Structural Supports for extended writing tasks
- Ongoing teacher feedback as part of the writing process
- Interactive Study Guides
- Multi-sensory approach to instruction
- Written and spoken step-by-step directions
- Graphic organizers
- Non-verbal cues to begin task/remain on task/refocus
- Individual monitoring for understanding/reinforced instruction
- Printed copies of class readings for application of Active Reading Strategies

504s
- Exemplars of varied performance levels
- Multimedia presentations
- Sheltered instruction
- Tiered/Scaffolded Lessons
- Mnemonic devices
- Visual aids
- Modeling
- Guided note-taking
- Study Guides

- Differentiated pre-typed class notes and example problems
- Manipulatives
- Words banks
- Reduced choice on assessments
- Preferential seating
- Modified time requirements
- Modified notes
- Modify lesson, assessment and study guide format
- Modified homework
- Independent projects
- Contracts/management plans
- Open-ended responses
- Project-based learning
- Group activities
- Guided Notes
- Exploration Activities
- Assessment read aloud
- Small group assessments
- Organizational Support
- Oral questioning assessments to supplement written response
- Pre-writing Structural Supports for extended writing tasks
- Ongoing teacher feedback as part of the writing process
- Interactive Study Guides
- Multi-sensory approach to instruction
- Written and spoken step-by-step directions
- Content-focused assessment (not grading for spelling/grammar)
- Graphic organizers
- Non-verbal cues to begin task/remain on task/refocus
- Individual monitoring for understanding/reinforced instruction
- Printed copies of class readings for application of Active Reading Strategies

Students at Risk of Failure
- Exemplars of varied performance levels
- Multimedia presentations
- Tiered/Scaffolded Lessons
- Modeling
- Guided note-taking
- Study Guides
- Differentiated pre-typed class notes and example problems
- Individualized instruction plans
- Words banks
- Reduced choice on assessments
- Preferential seating
- Choice activities
- Modified time requirements

- Modified notes
- Modified lesson, assessment and study guide format
- Modified homework
- Provide an enriched curriculum and activities
- Contracts/management plans
- Open-ended responses
- Project-based learning
- Group activities
- Guided Notes
- Exploration Activities
- Assessment read aloud
- Small group assessments
- Oral questioning assessments to supplement written response
- Pre-writing Structural Supports for extended writing tasks
- Ongoing teacher feedback as part of the writing process
- Interactive Study Guides
- Multi-sensory approach to instruction
- Written and spoken step-by-step directions
- Graphic organizers
- Non-verbal cues to begin task/remain on task/refocus
- Individual monitoring for understanding/reinforced instruction
- Printed copies of class readings for application of Active Reading Strategies

Diversity, Equity, and Inclusion Curriculum Statement

Berkeley Heights public schools are committed to recognizing diversity and promoting equity, tolerance, and inclusion in our classrooms. We encourage a safe, welcoming, and inclusive environment for all students regardless of race or ethnicity, sexual and gender identities, mental and physical disabilities, and religious beliefs. Our curriculum infuses teaching of these principles and addresses all associated standards and laws. This includes, but is not limited to:

C.18A:35-4.35 - History of disabled and LGBT persons

> *A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards.*

18A:35-28. Instruction on Holocaust, genocides required in elementary, secondary school curriculum

> *a. Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils.*

> *b. The instruction shall enable pupils to identify and analyze applicable theories concerning human nature and behavior; to understand that genocide is a consequence of prejudice and discrimination; and to understand that issues of moral dilemma and conscience have a profound impact on life. The instruction shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens.*

Section: 52:16A-88: Responsibilities, duties of Amistad Commission

> *g. to develop, in consultation with the Department of Education, curriculum guidelines for the teaching of information on the African slave trade, slavery in America, the vestiges of slavery in this country, and the contributions of African-Americans to our country. Every board of education shall incorporate the information in an appropriate place in the curriculum of elementary and secondary school students;*

Examples of how these concepts and principles are infused into this curriculum include:
- Spotlight Reports: students share monthly news or current event reports about current developments in 3 dimensional technologies related to Climate Change - **Ongoing**
- Discussion of the ideas and concepts around developing habitats in new and currently uncommon places; explore the concept of habitats on other planets, underwater and underground.

Additionally, components of this are tagged throughout the curriculum as appropriate (i.e. standards, objectives, activities). Tagging convention is outlined below:
- DEI - Diversity, Equity and Inclusion Learning
- AM - Learning associated with Amistad
- HG - Learning associated with Holocaust and Genocide

- SEL - Social-Emotional Learning
- L+ - Learning associated with LGBTQ+ and Neurodiverse communities

Climate Change Curriculum Statement

With the adoption of the 2020 New Jersey Student Learning Standards (NJSLS), New Jersey became the first state in the nation to include climate change across content areas. These standards are designed to prepare students to understand how and why climate change happens, the impact it has on our local and global communities and to act in informed and sustainable ways.

Districts are encouraged to utilize the NJSLS to develop interdisciplinary units focused on climate change that include authentic learning experiences, integrate a range of perspectives and are action oriented. While the 2016 NJSLS-English Language Arts (ELA) and Mathematics do not have specific climate change standards, districts may want to consider how they can design interdisciplinary climate change units that incorporate relevant ELA and mathematics standards. Likewise, it may be helpful to review the 2020 NJSLS documents to identify other relevant standards that might be incorporated as well as to understand the role of core ideas, performance expectations and practices in curriculum development and lesson planning.

Standards and/or activities addressed in this curriculum includes:
- 8.1.5.DA.4: Organize and present climate change data visually to highlight relationships or support a claim.
- 8.2.2.ETW.4: Explain how the disposal of or reusing a product affects the local and global environment.

Career Readiness, Life Literacies, and Key Skills Practices

Career Readiness, Life Literacies, and Key Skills Practices describe the habits of the mind that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increased college, career, and life success. These practices should be taught and reinforced in all content areas with increasingly higher levels of complexity and expectation as a student advances through a program of study.

2020 NJSLS - Career Readiness, Life Literacies, and Key Skills Practices	
CLKS-P1	Act as a responsible and contributing community member and employee.
CLKS-P2	Attend to financial well-being.
CLKS-P3	Consider the environmental, social and economic impacts of decisions
CLKS-P4	Demonstrate creativity and innovation.
CLKS-P5	Utilize critical thinking to make sense of problems and persevere in solving them.
CLKS-P6	Model integrity, ethical leadership and effective management.
CLKS-P7	Plan education and career paths aligned to personal goals.
CLKS-P8	Use technology to enhance productivity, increase collaboration and communicate effectively.
CLKS-P9	Work productively in teams while using cultural/global competence.

Pacing Guide

Unit Number	Unit Title	Suggested Pacing
1	Introduction to 3D Modeling	10 days
2	3D Printing a Design / Fabrication Methods	15 days
3	Engineering Design Application	10 days (concurrent with Units 1 &2)

SCOPE AND SEQUENCE
COURSE OUTLINE/STUDENT OBJECTIVE

Unit 1: Introduction to 3D Modeling

Duration: 10 days

Overview: Students will create a 3D model of an object using computer based software.

Technology: 8.2.8.ED.1-6; 8.2.8.NT.1,3,4, ;8.1.5.DA.4 <mark>CC;</mark> 8.2.2.ETW.4 <mark>CC</mark>

21st Century: CRP1,2,4,5,6,7,8,9,11,12

Cross-Curricular Connections: RST.6-8.3; RST.6-8.4; RST.6-8.7; MP1,2,3,4,5

Essential Questions:
- How do you describe a 3D object in order to create a model?
- How does the computer represent a 3D object?
- How do you control the size and shape of a complex 3D object?

Students Learning Objectives:
Students will know…
- *The steps required to navigate the 3D modeling environment.*
Students will be able to…
- *How to pan, zoom, and rotate the model*
- *Create basic shapes in a 3D environment*
- *How add and subtract shapes to create complex objects*

Possible Activities:
Complete the Introductory lessons in Tinkercad. https://www.tinkercad.com/learn/
- "Learning the moves"
- "Camera Controls"
- "Creating Holes"
- "Scale, Copy and Paste"
- "Key Ring, Letters"
- Design a game Piece.
  https://www.commonsense.org/education/lesson-plans/introduction-to-3d-printing-designprint-a-board-game-piece#0

Unit 2: 3D Printing a Design / Fabrication Methods

Duration: 15 days

Overview: Students will learn to take a 3D model and prepare it for fabrication in a 3D printer. Students will access their designs and modify based on the printed results. Students will compare 3D printing to other fabrication methods.

Technology: 8.1.8.CS.3; 8.2.2.ED.1-4

21st Century: CLKS-P1,3-6,8-9

Cross-Curricular Connections: RST.6-8.3; RST.6-8.4; RST.6-8.7; MP1,2,3,4,5

Essential Questions:
- How does layer height affect a 3D printed object?
- How does infill percentage and type affect the 3D printed object?
- What are the optimal settings for various different models based on their use?
- How do the features of a 3D model impact the printer settings?
- Was 3D printing historically inevitable? Why or why not?
- Has technology helped or hindered creativity? How?
- Is there any such thing as a product that cannot be improved?

Students Learning Objectives:
Students will know...
- How to modify various 3D printer parameters
- How to download and inspect 3D models for critical feature
Students will be able to…
- Scale and rotate an object to optimize the 3D printing and object features
- Follow safety rules while working with tools.
- Section a model in order to create a test print of a critical feature

Possible Activities:
- Download and print 3D objects for thingiverse while varying the print parameters
- Modify a design of an existing object to improve its properties

Unit 3: Engineering Design Application

Duration: 10 Days (Concurrent with Units 1 and 2)

Overview: Students utilize 3D modeling and 3D printing to complete a design challenge. They will leverage research and data collection to support and modify their design. Based on scientific concepts and validated research students will be able to support their design decisions and create modifications to the design model.

Technology: 8.2.2.ED.1-4; 8.2.2.ITH.1-5

21st Century: CLKS-P1,3-6,8-9

Cross-Curricular Connections: RST.6-8.3; RST.6-8.4; RST.6-8.7; MP1,2,3,4,5; MS-ETS1-4

Essential Questions:
- How can the Engineering Design Process be used to approach solving real world problems?
- How do you break a problem or design into components to simplify the design?
- How does 3D modeling and printing impact the way you designed your part?

Students Learning Objectives:
Students will know...
- How to research information that will guide their development of ideas.
- How to use brainstorming techniques to think outside of the box.
- How to apply the skill of technical drawing to interpret 3D objects from the front, side, and top.

Students will be able to…
- Students will apply their knowledge of the Engineering Design Process by completing design challenge.

Possible Activities:
- Rube Goldberg Machine
- Vertical Marble Maze
- 3D Bridge Construction
- 3D Tennis Ball Towers

SUGGESTED AUDIO VISUAL/COMPUTER AIDS

1. Graphing Calculator
2. iPad apps and peripherals
3. Discovery Channel's *Mythbusters*
4. http://video.mit.edu/
5. 3D Printer
6. Computer Interface probes
7. Force, Pressure and temperature sensors

SUGGESTED MATERIALS

Resources for Students
- Lego kits
- Glue Guns, Glue
- Balsa wood
- Paper
- 3D Printed Parts
- Tape/Duck Tape
- Balloons
- Straws
- Paper Clips
- Wood skewers
- CD's
- Rubber Bands
- String, Thread
- Screws
- Sketch design tools on iPad
- OneNote

Resources for Teacher

https://insidetheclassroomoutsidethebox.wordpress.com/2014/07/13/design-thinking-and-challenges/

https://dschool-old.stanford.edu/groups/k12/wiki/956b6/Design_Thinking_Projects_and_Challenges.html

https://designthinkingforeducators.com/

https://www.pinterest.com/pin/308355905708355267/

http://pbskids.org/designsquad/parentseducators/resources/index.html?type=activity

http://centerforstem.tcnj.edu/istem-home/resources/

*Or other literature, video, or digital materials of equal academic worth