STEM Creative Design G9-12

Ewing Public Schools
2099 Pennington Road
Ewing, NJ 08618

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Superintendent

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In accordance with The Ewing Public Schools' Policy 2230, Course Guides, this curriculum has been reviewed and found to be in compliance with all policies and all affirmative action criteria.

Table of Contents

Course Description and Rationale

In all aspects of modern society people are constantly interacting with man-made products and systems that we often take for granted and understand very little about. Where do products come from? How are they made? Why do they work the way they do? This course will answer those questions and many more as you learn about the fundamental elements and principles of design through a variety of hands-on projects and other collaborative experiences that will challenge your skills and creativity in a fun and engaging way. The course will also introduce you to the design process used by various professionals such as artists, engineers, and architects. You will be able to think critically about the choices you make as consumers, and develop habits of mind related to design choices.

This is a foundational course that looks at the elements and principles of design as related to practical products, systems, and environments. It introduces students to the creative process practiced by artists, designers, and engineers, valuable to them as both future producers and consumers. Content includes thinking, drawing, and modeling skills commonly used by designers; development of a design vocabulary; the nature and evolution of technological design; the impacts of design on the individual, society, and the environment; patents and intellectual property; human factors; team design; and appropriate technology, risk analysis, and futuring techniques. Design problems are presented within real-world contexts, using field trips and outside speakers. Students complete a major design project, document their work through a design portfolio, and present their solutions before the class. Weekly critiques of class projects build fluency, confidence, and creativity.

Unit 1: Design Process

Why Is This Unit Important?

The design process is used by various professionals such as artists, engineers, and architects.

Enduring Understandings:

- Engineering design is a complex process in which creativity, content knowledge, research, and analysis are used to address local and global problems.
- Decisions on trade-offs involve systematic comparisons of all costs and benefits, and final steps that may involve redesigning for optimization.
- Engineering design evaluation, a process for determining how well a solution meets requirements, involves systematic comparisons between requirements, specifications, and constraints.
- Trade-offs related to implementation, readability, and program performance are considered when selecting and combining control structures.
- Complex programs are designed as systems of interacting modules, each with a specific role, coordinating for a common overall purpose.
- Modules allow for better management of complex tasks.
- Complex programs are developed, tested, and analyzed by teams drawing on the members' diverse strengths using a variety of resources, libraries, and tools.
- Fundamental elements
- Principles of design

Essential Questions:

- What is the engineering design process?
- How is the EDP used to develop a product?
- What is industrial design?
- Where do products come from?
- How are products made?
- Why do products work the way they do?

Acquired Knowledge:

- Fundamental elements and principles of design
- Engineering Design Process
- Technical Sketches

Acquired Skills:

- Critical Thinking
- Problem Solving
- Design Thinking
- Habits of Mind
- Universal Design for Learning

Assessments:

Formative

- Preparation & Participation
- Reading Discussions
- Assignments
- Design Projects
- Exams
- Do Now’s
- Quizzes
- Guided Notes
- Classwork / Homework
- Exit Tickets

Summative

- Unit Tests
- Final Project

Suggested Learning Experiences and Instructional Activities:

- Lecture Introduction to industrial design
- Activity Product pitch
- Lecture The Design Process / Creativity in Design
- Lecture Brainstorming/Interview Techniques
- Activity Conducting Surveys
- Lecture Making Design Decisions Discussion
- Activity Morph chart and Evaluation Matrix
- Lecture Communication
- Activity- Group Presentations

Instructional Materials (including, but not limited to):

- Canvas
- Google Drive
- Sketch Notebook
- Scale or Straight Edge
- Colored Pencil Set
- Exacto-Knife
- Designkit.org
- The Art of Innovation (2001), Tom Kelley
- InGenius (2012), Tina Seelig
- Creative Confidence (2013), Tom Kelley & David Kelly

Computer Science and Design Thinking - 2020 New Jersey Student Learning Standards:

- 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 modifications to increase optimization based on feedback.
- 8.2.12.ED.3: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis.
- 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience.
- 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics).
- 8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, and labor).
- 8.1.12.AP.3: Select and combine control structures for a specific application based upon performance and readability, and identify trade-offs to justify the choice.
- 8.1.12.AP.4: Design and iteratively develop computational artifacts for practical intent, personal expression, or to address a societal issue.
- 8.1.12.AP.5: Decompose problems into smaller components through systematic analysis, using constructs such as procedures, modules, and/or objects.
- 8.1.12.AP.6: Create artifacts by using procedures within a program, combinations of data and procedures, or independent but interrelated programs.
- 8.1.12.AP.7: Collaboratively design and develop programs and artifacts for broad audiences by incorporating feedback from users.
- 8.1.12.AP.8: Evaluate and refine computational artifacts to make them more usable and accessible.
- 8.1.12.AP.9: Collaboratively document and present design decisions in the development of complex programs.

Unit 2: Visualizations

Why Is This Unit Important?

Data and communications can be delivered visually, but understanding how to develop visual content is key.

Enduring Understandings:

- Decisions to develop new technology are driven by societal and cultural opinions and demands that differ from culture to culture.
- Changes caused by the introduction and use of a new technology can range from gradual to rapid and from subtle to obvious, and can change over time. These changes may vary from society to society as a result of differences in a society's economy, politics, and culture.
- Individuals select digital tools and design automated processes to collect, transform, generalize, simplify, and present large data sets in different ways to influence how other people interpret and understand the underlying information.
- Choices individuals make about how and where data is organized and stored affects cost, speed, reliability, accessibility, privacy, and integrity.
- Large data sets can be transformed, generalized, simplified, and presented in different ways to influence how individuals interpret and understand the underlying information.
- The accuracy of predictions or inferences made from a computer model is affected by the amount, quality, and diversity of data.

Essential Questions:

- How can data be analyzed and represented?
- What is the purpose of innovation?

Acquired Knowledge:

- Isometric Drawings
- Orthographic Projections
- Perspective Sketches
- Technical Sketches

Acquired Skills:

- Critical Thinking
- Problem Solving
- Design Thinking
- Habits of Mind
- Universal Design for Learning

Assessments:

Formative Assessments

- Preparation & Participation
- Reading Discussions
- Assignments
- Design Projects
- Exams
- Do Nows
- Quizzes
- Guided Notes
- Classwork / Homework
- Exit Tickets

Summative

- Unit Tests
- Final Project

Suggested Learning Experiences and Instructional Activities:

- Lecture Visualization - Orthographic Drawings
- Discussion
- Lecture Visualization - Isometric Drawings

Instructional Materials (including, but not limited to):

- Canvas
- Google Drive
- Sketch Notebook
- Scale or Straight Edge
- Colored Pencil Set
- Exacto-Knife
- Designkit.org
- The Art of Innovation (2001), Tom Kelley
- InGenius (2012), Tina Seelig
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Computer Science and Design Thinking - 2020 New Jersey Student Learning Standards:

- 8.2.12.ITH.1: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design Constraints.
- 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.ITH.3: Analyze the impact that globalization, social media, and access to open source technologies has had on innovation and on a society's economy, politics, and culture.
- 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.
- 8.1.12.DA.2: Describe the trade-offs in how and where data is organized and stored.
- 8.1.12.DA.3: Translate between decimal numbers and binary numbers.
- 8.1.12.DA.4: Explain the relationship between binary numbers and the storage and use of data in a computing device.
- 8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
- 8.1.12.DA.6: Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.

Unit 3: Design Elements

Why Is This Unit Important?

The elements of design are the fundamental aspects of any visual design which include shape, color, space, form, line, value, and texture.

Enduring Understandings:

- Engineers use science, mathematics, and other disciplines to improve technology.
- Increased collaboration among engineers, scientists, and mathematicians can improve their work and designs.
- Technology, product, or system redesign can be more difficult than the original design.

Essential Questions:

- What is the design process?
- What are elements of design?

Acquired Knowledge:

- Engineering Design Process
- Elements of Design

Acquired Skills:

- Critical Thinking
- Problem Solving
- Design Thinking
- Habits of Mind
- Universal Design for Learning

Assessments:

Formative

- Preparation & Participation
- Reading Discussions
- Assignments
- Design Projects
- Exams
- Do Now’s
- Quizzes
- Guided Notes
- Classwork / Homework
- Exit Tickets

Summative

- Unit Tests
- Final Project

Suggested Learning Experiences and Instructional Activities:

- Drawing
- Design Process
- Activity: Line, Space & Texture
- Lecture: Design Elements
- Discussion #7 Chapter 6
- Activity: Form, Shape & Color

Instructional Materials (including, but not limited to):

- Canvas
- Google Drive
- Sketch Notebook
- Scale or Straight Edge
- Colored Pencil Set
- Exacto-Knife
- Designkit.org
- The Art of Innovation (2001), Tom Kelley
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- 8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
- 8.1.12.DA.6: Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.

Unit 4: Introduction to 3D Printing

Why Is This Unit Important?

Three-dimensional (3D) printing is an additive manufacturing process that creates a physical object from a digital design.3D printing is changing the world of production, but the technology can lead to much bigger change in society- by changing business models, transforming working environments and delivering added value and sustainability.

Enduring Understandings:

- The design and use of computing technologies and artifacts can positively or negatively affect equitable access to information and opportunities.

Essential Questions:

- How do I design in 3D?
- What industries might 3D printing disrupt, and how?

Acquired Knowledge:

- Basics of 3D Printing
- Parts of a 3D Printer
- TinkerCad Software
- Harmony & Balance

Acquired Skills:

- Critical Thinking
- Problem Solving
- Design Thinking
- Habits of Mind
- Universal Design for Learning

Assessments:

Formative

- Preparation & Participation
- Reading Discussions
- Assignments
- Design Projects
- Exams
- Do Now's
- Quizzes
- Guided Notes
- Classwork / Homework
- Exit Tickets

Summative

- Unit Tests
- Final Project

Suggested Learning Experiences and Instructional Activities:

- Lecture: Introduction to 3D Printing Discussion
- Activity: TinkerCad Software
- Lecture: Design Principles
- Online Reading
- Activity: Harmony & Balance
- Impacts of 3D Printing on Society

Instructional Materials (including, but not limited to):

- Canvas
- Google Drive
- Sketch Notebook
- Scale or Straight Edge
- Colored Pencil Set
- Exacto-Knife
- Designkit.org
- The Art of Innovation (2001), Tom Kelley
- InGenius (2012), Tina Seelig
- Creative Confidence (2013), Tom Kelley & David Kelly
- Tinkercad
- 3D Printing

Computer Science and Design Thinking - 2020 New Jersey Student Learning Standards:

- 8.1.12.IC.1: Evaluate the ways computing impacts personal, ethical, social, economic, and cultural practices.
- 8.1.12.IC.2: Test and refine computational artifacts to reduce bias and equity deficits.
- 8.1.12.IC.3: Predict the potential impacts and implications of emerging technologies on larger social, economic, and political structures, using evidence from credible sources.

Unit 5: Design Principles

Why Is This Unit Important?

Design principles are a set of considerations that form the basis of any good product. They help to keep important values front and center in the design process and improve decision making and product/ project completion.

Enduring Understandings:

- Development and modification of any technological system needs to take into account how the operation of the system will affect natural resources and ecosystems.
- Impacts of technological systems on the environment need to be monitored and must inform decision-making.
- Many technologies have been designed to have a positive impact on the environment and to monitor environmental change over time.

Essential Questions:

- How might design principles be incorporated in any industry?
- How does collaboration impact design?

Acquired Knowledge:

- Design Principles
- Rhythm, Emphasis, Proportion & Scale
- Sculpture Analysis

Acquired Skills:

- Critical Thinking
- Problem Solving
- Design Thinking
- Habits of Mind
- Universal Design for Learning

Assessments:

Formative

- Preparation & Participation
- Reading Discussions
- Assignments
- Design Projects
- Exams
- Do Now's
- Quizzes
- Guided Notes
- Classwork / Homework
- Exit Tickets

Summative

- Unit Tests
- Final Project

Suggested Learning Experiences and Instructional Activities:

- Lecture: Design Principles Discussion
- Online Reading
- Activity: Rhythm, Emphasis, Proportion & Scale
- Sculpture analysis

Instructional Materials (including, but not limited to):

- Canvas
- Google Drive
- Sketch Notebook
- Scale or Straight Edge
- Colored Pencil Set
- Exacto-Knife
- Designkit.org
- The Art of Innovation (2001), Tom Kelley
- InGenius (2012), Tina Seelig
- Creative Confidence (2013), Tom Kelley & David Kelly
- Tinkercad
- 3D Printing

Computer Science and Design Thinking - 2020 New Jersey Student Learning Standards:

- 8.2.12.ETW.1: Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation, and maintenance of a chosen product.
- 8.2.12.ETW.2: Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment.
- 8.2.12.ETW.3: Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.

Unit 6: Ergonomics & Human Centered Design

Why Is This Unit Important?

Human centered design is an approach to interactive systems that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ ergonomics, and usability knowledge and techniques.

Enduring Understandings:

- The ability to ethically integrate new technologies requires deciding whether to introduce a technology, taking into consideration local resources and the role of culture in acceptance.
- Consequences of technological use may be different for different groups of people and may change over time.
- Since technological decisions can have ethical implications, it is essential that individuals analyze issues by gathering evidence from multiple perspectives and conceiving of alternative possibilities before proposing solutions.

Essential Questions:

- How does the impact of technology vary between different groups of people?
- Why should design be human-centered?

Acquired Knowledge:

- Elements of Design
- Fundamental Principles of Design
- Form follows function

Acquired Skills:

- Critical Thinking
- Problem Solving
- Design Thinking
- Habits of Mind
- Universal Design for Learning

Assessments:

Formative

- Preparation & Participation
- Reading Discussions
- Assignments
- Design Projects
- Exams
- Do Now's
- Quizzes
- Guided Notes
- Classwork / Homework
- Exit Tickets

Summative

- Unit Tests
- Final Project

Suggested Learning Experiences and Instructional Activities:

- Lecture: Human Centered Design Project
- Exam: Design Process, Elements, Principles

Instructional Materials (including, but not limited to):

- Canvas
- Google Drive
- Sketch Notebook
- Scale or Straight Edge
- Colored Pencil Set
- Exacto-Knife
- Designkit.org
- The Art of Innovation (2001), Tom Kelley
- InGenius (2012), Tina Seelig
- Creative Confidence (2013), Tom Kelley & David Kelly
- Tinkercad
- 3D Printing

Computer Science and Design Thinking - 2020 New Jersey Student Learning Standards:

- 8.2.12.EC.1: Analyze controversial technological issues and determine the degree to which individuals, businesses, and governments have an ethical role in decisions that are made.
- 8.2.12.EC.2: Assess the positive and negative impacts of emerging technologies on developing countries and evaluate how individuals, non-profit organizations, and governments have responded.
- 8.2.12.EC.3: Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience.
- 8.2.12.ETW.4: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints.

Accommodations

Special Education Students

Peer to peer assistance; reduce / revise assignments as per IEP; use manipulatives; calculators; extra time to complete task; provide individual & small group help; notes, and study guides; provide background knowledge; flexible grouping; peer grouping; visual demonstration; text magnification; color coding; repetition; pre-teaching; chunking; differentiating content; preferential seating; rephrasing of directions

English Language Learners

Use consistent, simplified language; provide bilingual partner; provide cooperative learning opportunities; use modeling; use visual aids & manipulatives; scaffolding; chunking the content; subtitles for videos

Students at Risk of Failure

Foster positive relationships; use mental models; provide help formulating specific questions; scaffolding; targeted support

Gifted Students

Provide additional enrichment activity involving demonstration of knowledge, or complementary assignments; independent practice; extension activities

Suggested Pacing

Unit (topic)	Anticipated time frame (days)
Design Process	5
Visualizations	5
Design Elements	20
Introduction to 3D Printing	20
Design Principles	20
Ergonomics & Human Centered Design	20

Sample Standards Integration

During this course, in addition to the New Jersey Student Learning Standards for Computer Science and Design Thinking, students will work on developing, to an age appropriate level, standards across content areas, including:

Career Readiness, Life Literacies, and Key Skills
9.4.8.CI.4: Explore the role of creativity and innovation in career pathways and industries.
Students will connect the concepts and skills in this course to potential future careers.

Social Studies
6.1.12.EconNE.16.b: Evaluate the economic, political, and social impact of new and emerging technologies on individuals and nations.
Students will discuss the positive and negative impacts of technological advancements.

Science
MS-PS1-6: Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
Students will employ the design cycle to complete projects based on specific guidelines.

Mathematics
NJSLS-M.8.SP.A.2: Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit (e.g. line of best fit) by judging the closeness of the data points to the line.
Students will interpret, analyze, and discuss data on diversity in technology careers and education.

English Language Arts
NJSLSA.W6: Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
Students will engage in written discussion utilizing the district's digital learning environment.

Diversity, Equity & Inclusion

All students deserve equitable access (N.J.A.C. 6A:7) to a high-quality education that is inclusive and reflective of the rich diversity of our state. This curriculum will include learning activities that meet the legislative requirements of the 2019 History and Contributions of Individuals with Disabilities and LGBT (N.J.S.A. 18A:35-4.35-6) and Diversity and Inclusion statutes (N.J.S.A. 18A:35-4.36a) that may include:

- Students work in groups to develop a slide deck highlighting LGBTQ+ pioneers of computer science, such as Alan Turing, Edith Windsor, etc.
- Students will interpret, analyze, evaluate, and discuss data involving diversity in STEM fields (this may include the number of women enrolled in technology education programs, representation of people with disabilities in video games, etc.).