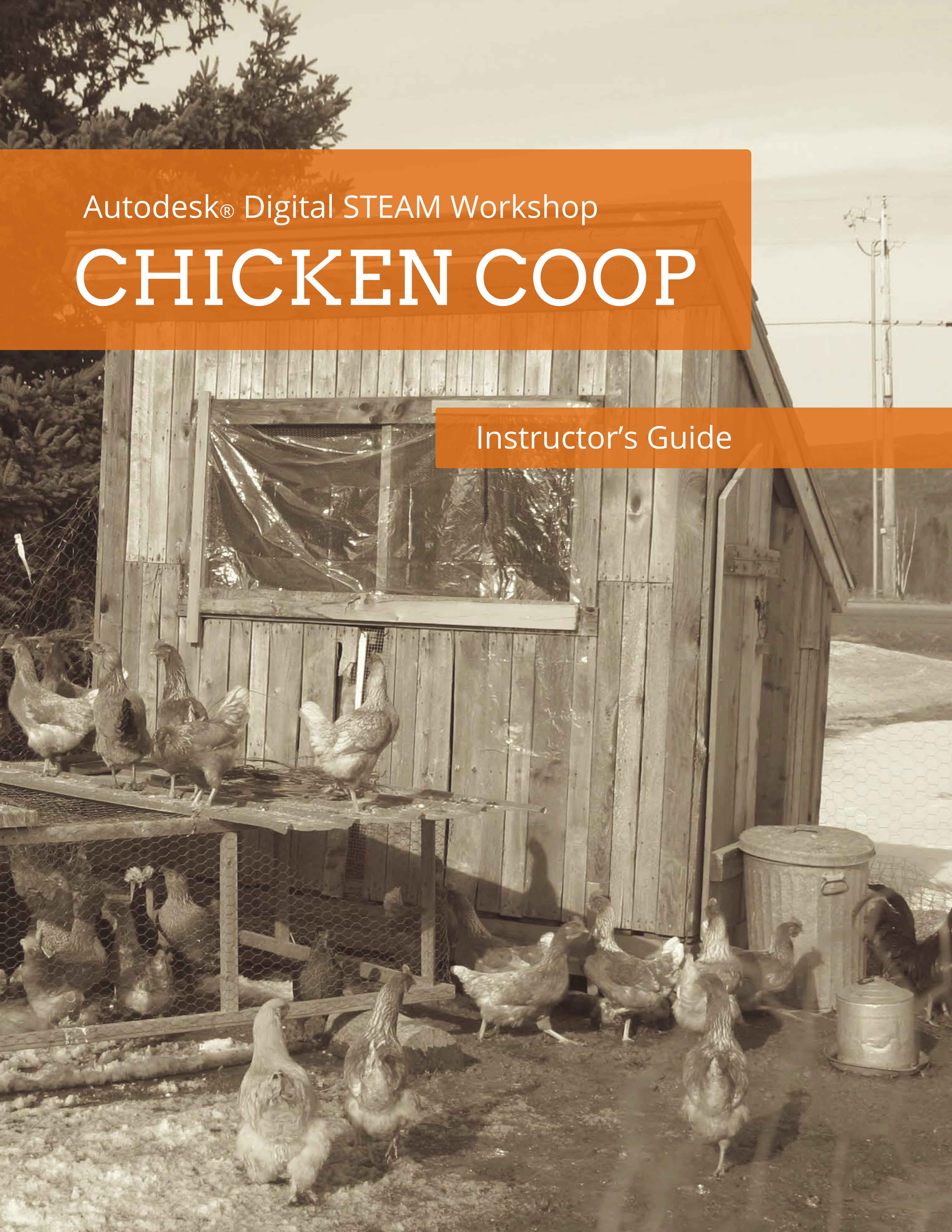


Autodesk® Digital STEAM Workshop

CHICKEN COOP

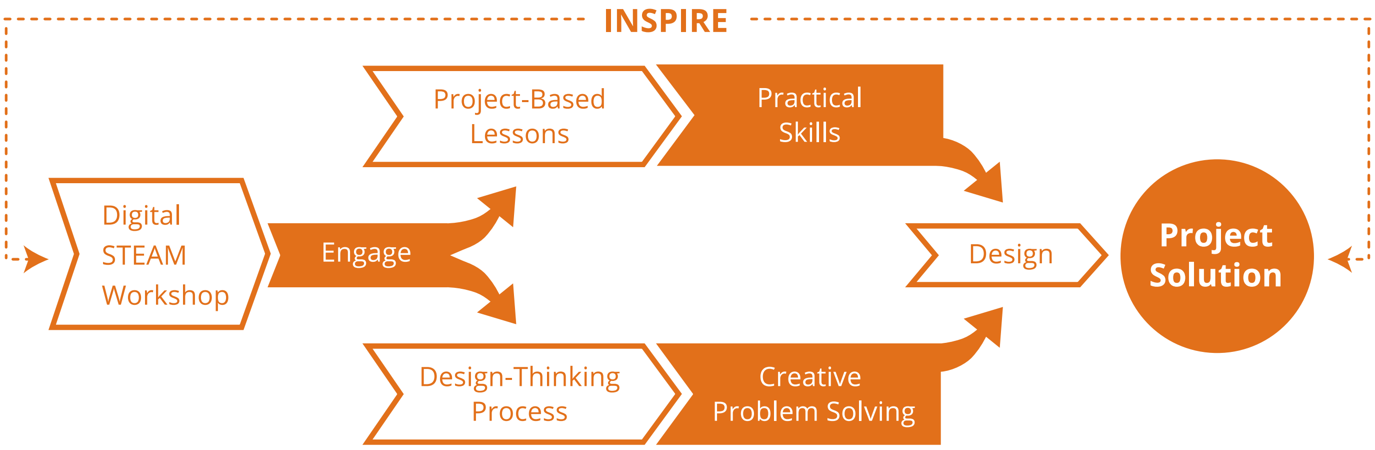
Instructor's Guide

Getting Started

In the chicken coop project, students will use the steps of Design Thinking to create their own chicken coop design in AutoCAD®. The materials in this Instructor's Guide will help you guide your students through the steps of Design Thinking and help them create successful designs, as well as give you the tools you need to provide context to the lesson, show connections to STEAM subjects, and evaluate your students' work. In the Instructor's Guide, you will find:

- Educator Resources that introduce Design Thinking and provide suggestions for how to teach the project to special needs students and non-native speakers.
- A lesson plan with learning objectives, key terms, suggestions for ways to connect the project concepts to STEAM, and Day-to-Day plans that walk you through teaching each step of the Design Thinking process in manageable, class-length sections.
- Assignments aligned to each phase of Design Thinking to give your students a framework for documenting their creativity.
- Rubrics to evaluate students' performance for each phase of Design Thinking.
- Academic Standards with a key to show how the project aligns to Common Core, NGSS, ITEA, and National Standards for Visual Arts.

Whether you want your students to recreate the chicken coop presented in this project, or create a design of their own, this Instructor's Guide will help you provide the support your students need to use 21st century skills to make creative and innovative designs.



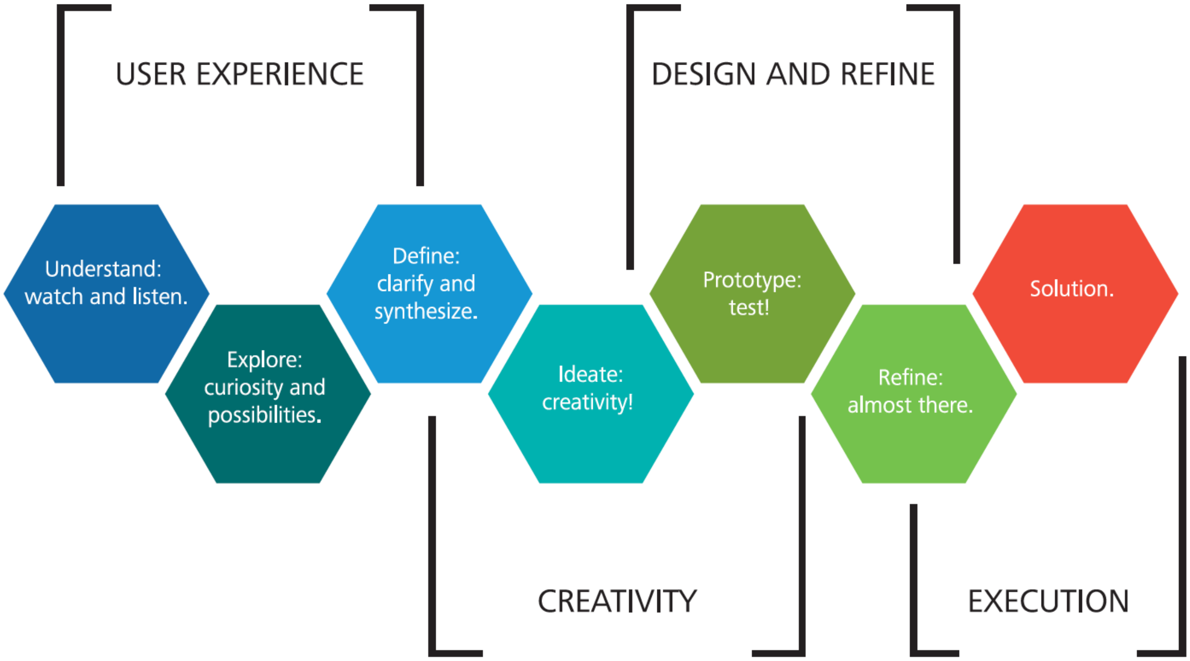
Getting Started

This project is directly aligned to the following Academic Standards:

- Common Core Standards for Mathematics: Geometry
- Common Core Standards for English Language Arts: Integration of Knowledge and Ideas, Research to Build and Present Knowledge, Comprehension and Collaboration, Presentation of Knowledge and Ideas
- NGSS Next Generation Science Standards: Interdependent Relationships in Ecosystems
- ITEA Standards for Technological Literacy: STL Standard 1, STL Standard 2, STL Standard 5, STL Standard 6, STL Standard 8, STL Standard 9, STL Standard 10, STL Standard 11, STL Standard 12, STL Standard 13, STL Standard 17, STL Standard 20.
- National Standards for Visual Arts: Making connections between visual arts and other disciplines

Table of Contents

Educator Resources



Design Thinking Guide

Design Thinking is a creative process for discovering opportunities and finding new ideas. It's about creative problem-solving, observation, and asking lots of questions in search of those new opportunities. It's about not fixating on the most obvious solution and asking important questions. By working through the Design Thinking Process, you can learn to suspend your judgment and look at things in a new way. Just because something has always been a certain way does not mean you can't question it; remember, not all chairs have to have four legs. Think of all the new and imaginative designs you see every day!

The Design Thinking Process is used to align the **Autodesk® Digital STEAM Workshop** projects with the creative process. The Design Thinking Process helps students understand that the creative process is similar for all design challenges and can be applied to many different types of projects.

The Autodesk Digital STEAM Workshop uses the seven-step process, which we believe will help teachers achieve the best results for their classes.

1. Understand: watch and listen.
First, students learn about the project by understanding what the challenge is from reviewing the project design brief and hearing the designer's own words.

Have the students read the project design brief and discuss how the designer solved the problem. Ask your students how they might come up with a solution and begin the brainstorming process.

2. Explore: curiosity and possibilities.
Following the designer's lead, have your students start exploring ideas and looking at other ways in which people have tackled similar issues.

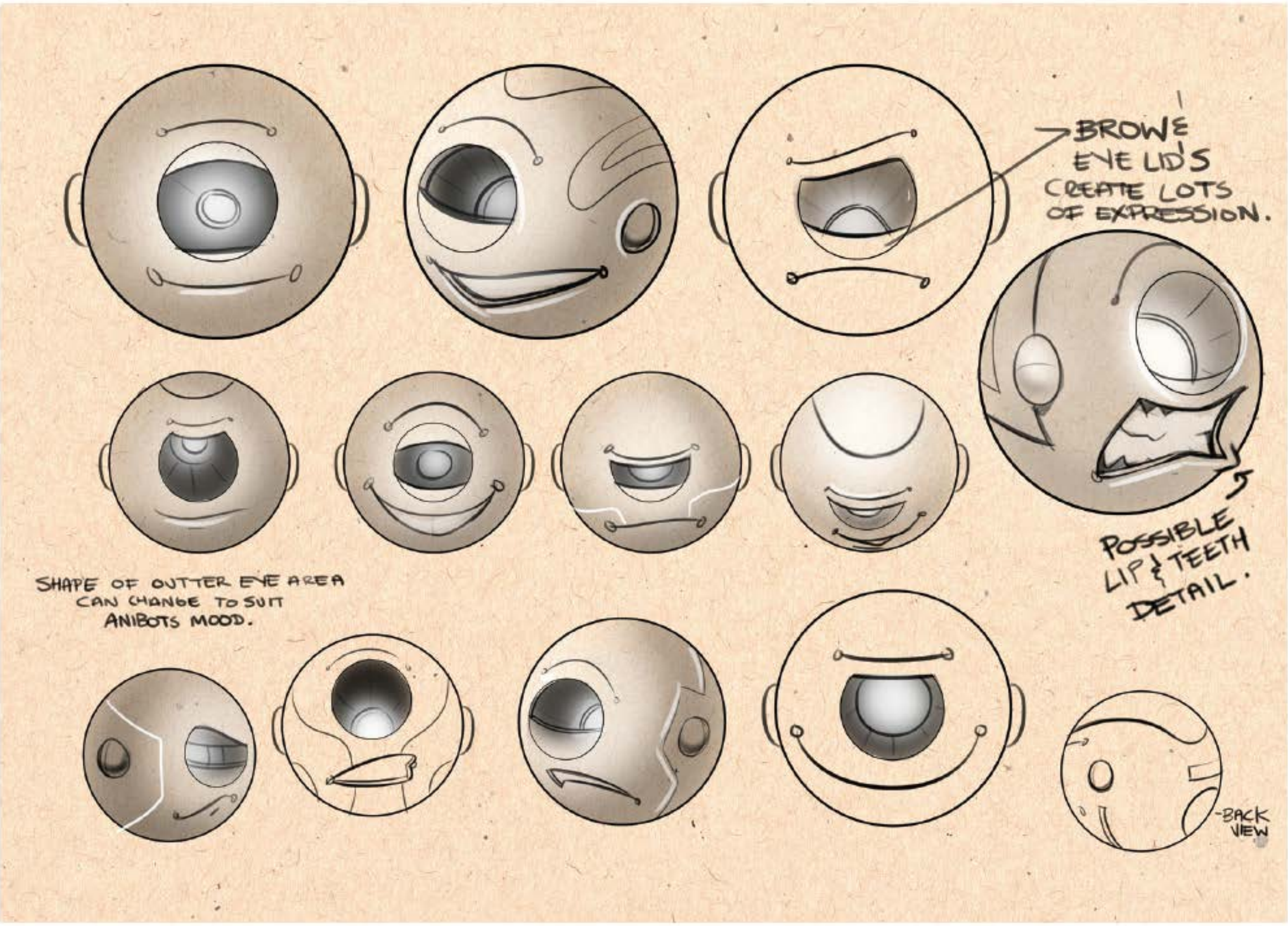
Have the students research and make notes, looking at different possibilities. Ask them to come up with as many ideas as possible, as quickly as they can, and then share their ideas with the class; sketching, writing, whatever it takes. Try to keep them from fixating on the most obvious solutions. Use a wall or blackboard to post notes of all the ideas on—and remember, no idea is a bad one!

3. Define: clarify and synthesize.
Now it's time for students to take what they came up with from the brainstorming session and define their concepts, using their research and reference material.

Have students choose what they believe are their best solutions and break down what it will take to transform those concepts that exists in their imagination into reality.

4. Ideate: creativity!
Sketching and hands-on activity such as creating paper models and mood boards are crucial in the Ideate phase.

Keep students inspired; no drawing is a bad drawing. You can start to explore shapes and process in the software at this stage. Remember, design is an iterative process. The ability to communicate a concept is a vital aspect of this design cycle, and students should explore materials.



Express Yourself concept sketches

5. Prototype: test!
In the Prototype phase, students can continue to explore hands-on prototypes as they work on their project design using the software.

A good starting tip is to have students make notes on their sketches, referring to software techniques that they might use to create their design. This helps them to begin thinking in a different way about translating their ideas. They can use the Digital Study Packet videos to reference techniques. Working in the software, students can also use the project tutorial videos and explore the datasets from the example projects as they learn the skills to transform their concepts into reality.

6. Refine: almost there.
Help the students find the resources they need in the software to make those final refinements to their design that will bring their ideas to life.

This stage will vary depending on how large the project is. Students should take this opportunity to explore alternative ways to resolve design issues, delving deeper into the software for techniques they might not have used before.

7. Solution.
Have the students use the software tools to visualize, animate, and present their projects the same way that real world professionals do every day.

Remember, design is an iterative process; no one says you can't rework your design, even after you have turned your project in for a grade. Who knows, maybe you can patent your design!

Get started today at:
www.autodesk.com/digitalsteam

Differentiated Instruction

- Encourage students to review the lesson and Skills videos in small groups.
- Have small teams of students collaborate to complete one design criteria worksheet by dividing up the work.
- Identify specific websites that students can use for the Define and Explore phases.
- Provide some students with a set of predefined design criteria and background content to modify the Define and Explore phases.
- Have small groups collaborate on the Ideate, Refine, Prototype, and Solution phases. Have some students focus on the development of physical sketches and sketch models while collaborating with team members who focus on digital prototyping.
- Provide students with self and peer evaluation forms to be filled out at the completion of each phase.
- Provide students with models of successful student presentations with clear examples of each design phase.

Non-Native Speakers

- Encourage students to tap into their own culture and life experience to discover prior knowledge of the project topic.
- Provide English/first-language translation dictionaries and/or electronic translation devices.

- Allow the student to prepare materials in their primary language and have it translated later.
- Pair ELL students with native English speakers.
- Provide a translator for viewing of videos.

Special Needs Students

- Provide prefabricated modeling components.
- Engage the help of aides to assist in physical sketch modeling and prototypes.
- Accommodate students by allowing additional time and/or reducing the scope of project requirements.
- Provide any necessary accommodations for access to technology such as alternative input devices, larger font sizes, speech recognition, and so on.

Assessment Processes

The assignments for all of the projects in this curriculum provide students with critical thinking exercises for each of the seven phases of Design Thinking. The rubrics serve to guide students in knowing what is expected for each phase and the criteria used to evaluate the quality of the work. For each project, students should collaborate with their peers throughout every step of Design Thinking. There is a collaboration rubric for each phase so students and instructors can measure how well they collaborated with others.

The STEAM connections, Extension Ideas, and the optional Build It activity offer students an opportunity to assess what they have learned and apply that knowledge to improve the quality their work and increase their scores.

Lesson Plan: Chicken Coop

Project Overview

As the interest in environmental sustainability grows globally, so does the trend toward the production and consumption of foods grown locally—grown even as close to home as the backyard. The number of chicken coops and small gardens in urban areas is rising. In this project, students design a functional, beautiful, thoughtful home for their feathered clients, taking into consideration requirements such as client needs (in this case, the chickens), location, function, aesthetics, and sustainability. By engaging in the seven design thinking phases for this project, students have the opportunity to develop their competencies in critical thinking, collaboration, creativity, and communication.

Software: AutoCAD®
Time: 6 to 10 hours
Level: Beginner
Subject(s): Architecture, Art, Engineering, Science, Math

Teacher Preparation

1. Read the Design Thinking Guide.

2. Watch all of the videos included in the Designer's Guide (download from main project page).

3. Be prepared to partner with your students in learning the new software techniques. Watch the videos in the How-to Videos section of the site to get you started.

4. Show students how to find help in the curriculum and use the software Help feature.

5. Point out which How-to Videos the students need to catch up on if they need a reference.

STEAM Connections

Background

If you think about it, the chicken coop involves the design and fabrication of two important but very different shelter structures. Of course, there is the coop, which is constructed like a small home, a frame with a sheet material cladding (such as plywood). The other "structure" is the egg, which provides a protective "shelter" that offers a nurturing environment for a fertilized egg to evolve into a chick whose entrance into the world requires cracking open his former home.

S	T	E	A	M
Biology of chickens Chemistry of Feed and Manure Environmental impact Nutrition of eggs Physics of egg structures	Design visualization through AutoCAD Thermal/ Structural Properties of materials Commercial vs. small- scale organic egg production	Green building practices Design for mass production Structural engineering principles	Form Color Texture Balance Material choice Architectural styling	Algebra of egg production Geometry of coops Trigonometry of roofs and ramps Math of solar orientation

Science

- An egg can be thought of as a monolithic structure because it is created out of a single material. How does a chicken's biological makeup support egg production? What is the basic molecular composition of the shell? Are there variations in egg-shell design and composition among breeds of chickens? What determines the shape of an egg and why do eggs laid by particular hens exhibit similarities in terms of shape and size? Why are egg shells stronger in the vertical axis as compared to the shorter, horizontal axis?

- Unlike the egg, most chicken coop structures are constructed out of a variety of different materials. One important criterion for a successful coop design involves the appropriate selection of construction materials to provide thermal insulation that enables the chickens to stay warm during cold months and cool in warm months. Conduct an investigation into the physical properties of several building materials that can be used for the coop. Describe the thermal characteristics of the materials, and explain how the composition and molecular structures determine those thermal properties.

Technology

- The single material composition and organic shape of an egg can be a source of inspiration for designing new types of shelters. Investigate construction systems that use a wire armature over which materials such as concrete are sprayed to create a shell-like structure. What types of aggregate materials can be combined in a concrete mix to increase strength, thermal efficiency, and resistance from corrosion by the forces of nature? What are the advantages and disadvantages of a monolithic design in terms of cost, appearance, and functionality?

- Chicken coops often incorporate some method of providing heat. A radiant source of heat, for example, a heat lamp or heater, requires an electrical source. How feasible is it to use solar PV panels as a source of electricity to provide heating and lighting? How do PV panels convert sunlight into usable electricity? How is the direct current produced by the panels converted to operate a heater or lighting? Based on the design of your coop, what size panels will be required in terms of wattage? What factors must be considered when determining how a panel is mounted and oriented relative to the sun. How is a backup energy supply created when sunlight is not available?

Engineering

- The proliferation of alternative practices, such as home-based chicken coops and organic gardens, can be viewed as part of a widespread movement towards sustainable living. A significant aspect of environmental sustainability linked to this particular project is the emergence of green building practices. Investigate a variety of green building practices related to the following aspects of a building structure: alternative insulation systems, low-E window glazing, innovative uses of shading, renewable energy production, water capturing and reuse, and alternative wall construction methods such as rammed earth and adobe.

- The project, as originally presented, focused on the design of a chicken coop that would be built on-site. Imagine what a coop might look like if it was designed to be pre-manufactured in ready-to-assemble modules. These "kits" could be ordered online or from catalogs. After arriving on-site, the kits would be assembled and properly secured. How would the development of a high-volume, mass-production coop design impact choices regarding materials, connection systems, and manufacturing processes used to fabricate all of the components? How would a ready-to-assemble, pre-manufactured chicken coop compare to a chicken coop constructed on-site in terms of cost, durability, appearance, and functionality?

Art

- A quick online search of chicken coop designs will reveal a wide array of architectural styles. What are some of the more intriguing styles? What is their historical significance and what are the key elements that make them unique?

- One of the design concepts that Emily presented in her video incorporated an exercise area that formed a connection between the two main coop boxes. This "bridge" incorporated a series of progressively skewed wooden planks that gave the coop a sculptural appearance. Can you identify some sculptures or sculptural buildings that can inspire your own design? Can you identify some forms in nature that can serve as an inspiration for designs that might transform a coop into a work of art? Use some of these inspirational sources to push your ideas further.

Math

- What is the minimum volume/area required by each chicken? Will you need to build a second coop if your flock grows in size? Can you stack the coops? If so, will this increase the required area/volume needed to house the coops?

- To make maximum use of materials and/or prepare to create a production process, think about creating sides, floors, doors, roofs as tessellation tiles that have no gaps between pieces. What shape(s) will work best?

- Calculate the surface area of the coop that needs to be painted, tiled, or carpeted and have minimized heat transfer. Areas of basic shapes (parallelogram, trapezoid, rectangle, square, circle, triangle) will work for skill levels up to Algebra I. Areas of shapes that are combinations of the basic shapes and additional shapes (segments, sectors) apply to the Algebra I to Algebra II skill levels. Skill levels through calculus may find areas of more complex shapes, including the area under a curve.

Project Discussion Guide

Use the discussion questions below to get your students thinking about the reasons for building a bicycle pavilion and the factors that will impact their design.

Conceptual Questions

Why do you think there is a growing worldwide interest in the issue of environmental sustainability?

What factors have influenced a growing interest in home-based food production?

What are some of the benefits associated with raising chickens in a residential environment?

What are some of the potentially negative aspects of raising chickens in a residential environment?

Design Questions

What are some of the important features that should be incorporated into a chicken coop design to assure the health and safety of the chickens and the humans who come in contact with them?

What are some of the key differences of designing a chicken coop for a rural, suburban, or urban environment?

What are some of the key green design principles that should be considered when designing a chicken coop?

What are some of the key structural elements that make a building structure stable and secure against the forces of nature?

What sorts of limits and opportunities does a $500.00 budget present for the design of a chicken coop?

Learning Objectives

After completing this project, you will be able to:

Explain the basic principles of a user-centered research inquiry.

Describe how a design criteria worksheet can guide the design development process.

Explain the basic elements of the seven design thinking phases.

Explain how physical sketch models, 2D sketches, and digital models can be used as visualization tools for design ideation.

Use AutoCAD to refine design concepts into detailed drawings that can be used for presentation and construction.

Prerequisites

Have the students watch these How-to Videos to prepare for the project:

- Manipulating Objects
- Object Snaps
- Modify Objects
- Creating Objects: Video One
- Layers
- Creating Objects: Video Two
- Altering Objects
- Hatching Objects
- Annotation

Key Terms

User-centered research, or using observational methods to study and understand people in both social and physical settings, is a powerful and increasingly widespread technique for uncovering unmet user needs and desires.

Ethnography is a detailed study of a group to describe its behavior, characteristics, cultural mores, and so on.

Green building is the practice of creating structures using processes that are environmentally responsible and resource-efficient throughout a building's lifecycle, from determining coop location to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classic building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high-performance building.

Mass production involves the manufacturing of large quantities of standardized products, frequently using assembly line technology. Mass production refers to the process of creating large numbers of similar products efficiently.

Sketch model refers to a model fabricated quickly at low cost, using easy-to-manipulate materials for the purpose of exploring multiple ideas.

Prototype is a physical or virtual model used to evaluate the technical or manufacturing feasibility of a particular 3D design product concept, technology, process, end item, or system.

Day-to-Day Plans

Use these plans to divide the project into sections centered on the steps of Design Thinking.

Hours 1 – 2

? Understand: Watch and Listen

To establish a solid foundation for the chicken coop project, students need to have a clear understanding of the challenge. The best starting point is to carefully review the project page and then watch the Understand video to hear Emily Pilloton, the project designer, describe the challenge. Distribute the Understand: Chicken Coop assignment and have students develop their responses to the questions.

Next, facilitate a student discussion built around the assignment questions. These can be conducted as a full class or small group discussions. As presented in the video, the primary goal of this phase is for your students to establish an understanding of the purpose for the chicken coop as the basis for developing a successful design solution.

Note: It is important to decide whether you will have students develop the chicken coop design described in the instructional videos, or if you want your students to follow the design process as a way of developing a chicken coop design for a site that they or your class determines.

Explore: Develop a Knowledge Base

Have students watch the Explore video. Note how Emily sees Define and Explore as two tightly connected phases. Through the Explore process, you want students to develop a full understanding of the clients. This understanding helps students to subsequently fill in specific data on the design criteria worksheet.

A good place to start is by forming teams so students can discuss the project conceptual and design questions listed above. The Explore video also provides good background information.

The next step is for students to develop a game plan for filling in knowledge gaps. Students should identify what they already know about chickens and structures; from there they can generate a list of unknowns using the Explore: Develop a Knowledge Base assignment.

Depending on the time available, this inquiry can range from brief online research to more formal research practices like interviewing people who own and maintain coops, or spending time closely observing chickens as they interact with a coop.

Note: It is critical for students to keep track of their findings in a notebook or journal. In some instances, digital photography and videotaping can serve as an excellent medium for capturing important insights.

Define: Clarify Requirements

As Emily states in the Define video, this critical stage in the design process involves establishing the criteria for the project; she refers to it as creating a "punch list" in which students identify all of the important factors that must be addressed. These factors include items such as coop location (rural, suburban, urban), the particular breed of chickens to be housed, and the physical and emotional needs of the chickens such as access to food and water, room to exercise, space to roost, protection from predators, and weather extremes. The criteria must also clarify the functional and aesthetic needs and desires of the humans who will interact with the chickens and the coop, as well as the humans who live near the coop. Ask your students to complete the Define: Design Criteria Worksheet assignment to help them define their designs.

Hours 3-6

Ideate: Creativity

This is the time for students to come up with as many ideas as possible for their chicken coop. While you want students to explore many concepts, remind them that it is good practice to keep some of the design criteria in the back of their minds as they explore ideas. Throughout the Ideate phase, a variety of techniques can be used to visualize a wide range of possibilities:

- 2D sketches on paper
- 2D sketches using Sketchbook® Express
- Quick-form studies or sketch models
- Virtual models using Autodesk software

The goal is to get students to visually communicate to themselves and others the essential direction they will take and refine in the next phase of prototyping. Once students have sketched out their initial designs, ask them to write a Project Brief to formally present their ideas.

Prototype: Test

In this phase, students use key concepts derived from the Ideate phase to create physical models and virtual prototypes with the software. Students can use the Designer's Guide to watch the project tutorial videos, explore the datasets from the example project, and refer back to the How-to Videos as they learn the skills that will transform their concepts into reality. Encourage students to assist each other in learning the software. Students can use the Prototype: Test worksheet to test the strength of their design, and learn how factors like the position of the sun, geological conditions, and climate can impact their design.

Hours 7-10

Refine: Almost There

In this phase, you want your students to leverage the power of the software to refine aspects of the design. As students proceed through this phase, remind them to keep referring back to the basic criteria previously established. Encourage students to use the Refine: It's all in the details! assignment to ask themselves if the details they are incorporating help define a design that fulfills the functional and emotional needs and desires of the "clients" (the chickens, their caretakers, and others who reside in proximity to the coop).

Solution: Final Presentation

This phase is vital for preparing for future success in school, careers, and life in general. The Solution phase is where you ask students to demonstrate how this project has helped them expand and enhance the four Cs of their learning and innovation skills: critical thinking, communication, collaboration, and creativity.

Instruct the students to prepare and conduct small group presentations that capture the important aspects of each of the previous phases. Ideally, students should be aware from the outset that the results of their efforts in design phases 1 – 7 will culminate in a final presentation. To facilitate this awareness, ask students to complete the Solution: What did you learn? assignment to reflect on what they learned from the design thinking process.

Note: Emphasize that a successful presentation must clearly define the problem that guided the design and articulate the key criteria that are addressed in the solution.

Stress the importance of using software tools to visualize, animate, and present the same way real professionals do every day. Remind students that many colleges, universities, and employers place high value on digital portfolios that convey how a student thinks, how they work with others, how they can generate creative solutions, and how they communicate their ideas and knowledge through a variety of written, visual, and oral formats. By investing effort into this project, your students will be one step closer to their goal for careers and/or college. You can even ask your students to create a physical model of their design, as a professional designer would.

Note: IIf time is limited, you may opt to have students share their final presentation electronically. This provides an opportunity to generate feedback from peers and teacher.

Build It

When you ask an adult what they remember most about school, the answer often refers to something they produced—something they built, wrote, performed, or generated through some form of visual media. Such activities can take extra time, but the benefits are worth it. It is hard to engage in the chicken coop project and not think about the possibility of taking the best design and building a full-size version. Cost is always a determining factor; however, it is quite conceivable that someone in the community would be very happy to pay for materials and even labor as a way of acquiring a coop for their yard. Engage the students in a review of the designs that they developed. Guide them in deciding what criteria should be used to determine the best design to build. Key variables will include the level of fabrication complexity, the size relative to the prospective clients, available space, and, of course, the aesthetics as they relate to the clients design sensibilities.

While this can be a time-consuming endeavor, students can gain a great deal of insight about how design and engineering practices are shaped by the realities of running a commercial enterprise.

Extension Ideas

- Use Autodesk® Inventor® software to detail a design for an automated chicken feed dispenser.

- Use Autodesk® Maya® software to generate an animation of how the coop design will function for humans and chickens.

- Ask your students to keep a Design Journal to document their work and findings through each step of the project. This can include notes, concept sketches, photographs of inspirational designs, screenshots from their work in the software, etc.

- Ask your students to "pitch" their design to various clients. These can include presentations to farmers, city officials, neighbors, etc. How would the presentation change based on the audience they're presenting to?

- Make connections to STEAM. What's the science behind chickens' nesting habits? What geometrical concepts will help students understand how to build a chicken coop that is space efficient?

Assignments

The assignments below follow the 7 steps of Design Thinking. As your students walk through this project and watch the How-to videos, have them use these assignments to guide their work.

Understand: Chicken Coop.
In this assignment, students will learn more about the social and environmental issues behind the chicken coop project.

Explore: Develop a Knowledge Base.
In this assignment, students are given research prompts to help them learn some of important concepts related to designing a chicken coop.

Define: Design Criteria Worksheet.
In this assignment, students define the needs that their design should address.

Ideate: Write a Project Brief.
In this assignment, students write a Project Brief to describe their design and explain how if fulfills the needs they identified in the Define phase.

Prototype: Test Your Design.
In this assignment, the students test how well their design holds up given different conditions.

Refine: It's all in the Details!
In this assignment, students ensure that their design is within project parameters and meets the needs of their audience.

Solution: What did you learn?
In this assignment, students reflect on the Design Thinking process and what they learned in creating their own design.

Understand: Bicycle Pavilion

Use the questions below to start thinking about designing a chicken coop, understand what problems chicken coops help address, and identify the social and environmental reasons for building chicken coops.

Why do you think there is a growing worldwide interest in the issue of environmental sustainability?

In recent years, more and more individuals and families have been involved in producing their own food. What do you think are some of the key factors influencing this trend?

What are some of the benefits associated with raising chickens in a residential environment?

What are some of the potential negative aspects of raising chickens in a residential environment?

Survey

To what extent would you agree or disagree with the following statements:

1 - Strongly disagree | 2 - Somewhat disagree | 3 - Neutral | 4 - Somewhat agree | 5 - Strongly agree

Based on the discussion and my own experience…	Rating
I know a lot about environmental sustainability.	
I understand why there is a growing interest by families and individuals in raising their own food.	
I understand why many people want to have a chicken coop in their backyard.	
I know a lot about chickens, chicken coops, and the factors that determine chicken coop design requirements.	
I have used AutoCAD before and I am comfortable using the software.	
I have a solid understanding of the seven phases of design thinking.	

What Do You Picture?

Based on your discussions and thinking about your responses to the survey, sketch a few ideas that immediately come into your mind. It can be anything!

Explore: Develop a Knowledge Base

Now that you understand the design challenge behind the chicken coop, do some research to learn more about your target audience, natural conditions that will impact your design, potential building sites, different tools you can use to build your design, and the principles of green building design. Here are some prompts to get you started:

Who is your target audience? User-centered research helps engineers and designers establish a solid foundation for the development of effective design solutions. List some of the characteristics of your target audience below. Which characteristics will have an impact on your design?

What are some potential building sites? What are the environmental conditions of these sites? Understanding these conditions is essential to avoid damage to an ecosystem, prevent structural failure, assess the real costs of design and construction, and obtain all necessary permits. List the environmental and geological conditions of potential sites that you will need to consider when creating your design.

What are the differences between urban and rural environments? What are some ways to adapt a design to an urban environment vs. a rural environment? How can you build a structure that is space efficient?

Engineers and designers use a variety of tools and techniques, ranging from freehand pencil sketches to sophisticated digital models, to explore ideas and communicate concepts and technical directions to others. What are some of these tools and techniques? What are the advantages/disadvantages of digital models vs. pencil sketches?

What are some principles of green building design? What are some sustainable building materials? What are some ways to design a chicken coop to make it more energy efficient?

Define: Design Criteria Worksheet: Chicken Coop

To develop innovative project solutions, it is critical to develop a clear understanding of all the criteria the design requires. This worksheet is intended to help you identify important factors that shape this project by prompting a response to questions in four key categories: who, where, what, and why. Watch the Design Thinking videos in the Designer's Guide to spark your ideas, or use your critical thinking skills to answer these questions based on your unique chicken coop design ideas.

Who

Who will occupy the chicken coop?

What are their physical needs?

What are their emotional needs?

What are some key physical characteristics of the coop occupants?

Who will interact with the coop and the coop's occupants?

What are their physical needs?

What are their emotional needs?

How will they interact with the coop and its occupants

Who will own the coop and pay for its construction and upkeep?

What is the budget for construction and upkeep?

How long will they want the coop to last?

How would you describe their aesthetic preferences with respect to the coop design?

Who will live or work in close proximity to the coop?

What concerns might they have?

How might a coop either please or annoy a neighbor?

Who might threaten the safety of the coop occupants?

Why would they be interested in the occupants?

What physical characteristics or special abilities would they have that could endanger the occupants?

Who has influence over the type, size, and location of a residential chicken coop?

What concerns might they have that will impact their decisions about type, size, and location?

Where

Where will the coop be located?

How much space is available for the coop?

What are the annual weather conditions?

What is the proximity to other people or buildings?

What are the geologic conditions of the site?

What are the traffic conditions near the site?

What zoning restrictions impact the design?

How will the site location impact the health and safety of the occupants?

How will the site location impact the health and safety of people who interact with the coop?

Where will the coop be constructed?

Will the coop be constructed on site?

Will the coop be pre-manufactured and assembled on site?

Will the coop be permanent or temporary?

What

What types of materials are best suited for the chicken coop?

Will the coop require materials that are durable?

Will the materials have to reflect a certain type of aesthetic?

Will the budget limit the type of materials that can be used?

Will certain materials pose a danger to the coop occupants or those who interact with the coop?

Can recycled materials be used?

What types of designs and construction methods are best suited for the site?

What skills and equipment will the coop builder have?

What types of chickens are best suited for the site?

What characteristics of certain chickens make them best suited for the site?

Why

Why is the client interested in raising chickens and placing a coop at their site?

Will the coop be used for commercial purposes?

Will the coop be used for personal enjoyment and home food production?

Will the coop convey some type of social status?

Will the coop symbolize some type of attitude regarding environmental sustainability?

Why do some communities encourage home-based raising chickens and residential coops?

What are the economic benefits of promoting residential chicken coops?

How does the practice of raising chickens in residential settings intact the broader community?

Ideate: Write a Project Brief

Professional designers use project briefs to give an overview of a project, state the requirements for a project, and define the project parameters. Use the interactive exercise below to write your own project brief for the chicken coop you started to design in the Ideate phase. Imagine that you are a professional architect with your own firm and you need to convince your stakeholders (investors, city officials, government agencies, community) that they should hire you to create the design. When writing your brief, keep in mind the research you did in the Understand and Explore phases, and the factors (budget, size, and location) that you identified in the Define phase. To help you get started, research design briefs online to see how professional designers present their ideas, what kind of language they use to describe their projects, and what information they include.

First, introduce yourself to the client. What is your business and where are you located? Why are you the best designer for the job? What are some examples of similar projects you've done?

What are the project goals? Why are they important? How will your design address these goals? (HINT: look at your answers from the Design Criteria Worksheet)

What are the parameters for the project (purpose, location, audience, size limitations, materials, budget, building code, and zoning restrictions) and how are you going to address them?

What materials will you use? How will these materials ensure that the design you create is environmentally sustainable?

What innovations make your design unique? How did you use principles of environmental sustainability in creating your design?

What else do you want to share about your design?

Prototype: Test your design!

Now that you've created your initial concept sketches and built a prototype in AutoCAD, test your design by considering the following factors, as well as how your design would need to change if you incorporated each factor.

Change the position of your coop. How does this affect how the sun hits the coop? Would this change negatively impact the lifestyle of the chickens? What changes would you need to make to your design to account for this?

Imagine that you built your design in a city where there is not much space for a chicken coop. How would the lack of space change the design? If you already designed your coop to be housed in an urban environment, how would you adapt it so that it is suited to a rural environment?

What is the climate like at your building site? Is it windy, rainy, hot, or cold? If the climate conditions of your building site changed (from a hot location to a snowy one, or a rainy location to a sunny one), how would you need to change your design?

Refine: It’s all in the details!

Now that you’re putting the finishing touches on your design, go back to the Design Criteria Worksheet you completed in the Define phase and your Project Brief from the Ideate phase, and answer the following questions.

How does your final design meet the needs of your target audience?

How does your design meet the project parameters that were outlined in the Project Brief?

What changes do you need to make to your design to achieve your goals?

Solution: What did you learn?

Now that you have completed this project, reflect on the activities you completed for each step of Design Thinking, and answer the questions below. Then, consider how the processes you used in this project could be applied to a different project. What other ideas for great designs do you have?

What are the steps of Design Thinking? How did you find them helpful in creating your design?

What obstacles did the Design Thinking process help you overcome? Did you discover any challenges that you would not have otherwise?

In the Understand phase, you learned about the design challenge and what the larger social and environmental concepts behind the design are. How has your understanding of these concepts changed now that you've completed your design?

In the Explore phase, you researched factors that would influence your design. How did this research affect your final design? Were there any subjects you researched that you want to explore further?

In the Define phase you completed a worksheet to define what needs your design had to address. Now that you've completed your design, what are some additional needs you think your design could address? What did you learn about addressing these various needs using design?

In the Ideate phase, you wrote a project brief to present your plan for your design. If design parameters changed, how would you change your design? For instance, if the budget for your design increased, what would you add to your design?

In the Prototype phase, you tested your design to see how it would hold up in different conditions. Did you see any patterns in how the design changed given different conditions? For example, when the position of the sun in relation to the building changed, what did you notice about the ideal location for your coop?

In the Refine phase, you put the finishing touches to your design and ensured that your design met project parameters. When adding finishing touches, did you notice any ways you could have improved your design overall to make the process easier? What were they?

Beyond Chicken Coops

Envision a real-world challenge or problem to which you could apply the skills and concepts acquired from this project to develop innovative solutions. This can be anything: a service, a new product, something to entertain or to inform—use your imagination! Share your thoughts in words, sketches, or some of your own digital models.

When professional designers complete a project, they often make a physical prototype of their design, to illustrate to clients and the community what their final design will look like. Using paper, cardboard, wood, or even 3D printed parts, create a physical prototype of your chicken coop design. Share your design with your class, or go even further and build a chicken coop to house your feathered friends!

Rubrics

Prerequisite Skills Preparation Evaluation Rubric

	Excellent	Good	Fair	Poor
How-to Videos	Great care was taken in using the How-to Videos to develop the necessary skills for the project.	Care was taken in using the How-to Videos to develop the necessary skills for the project.	A minimal amount of care was taken to use the How-to Videos to develop the necessary skills for the project.	No care was taken to use the How-to Videos to develop the necessary skills for the project.
Collaboration & Participation	Exceptional effort was made by the student to work with others to develop competencies with the prerequisite skills.	Reasonable effort was made by the student to work with others to develop competencies with the prerequisite skills.	Minimal effort was made by the student to work with others to develop competencies with the prerequisite skills.	No effort was made by the student to work with others to develop competencies with the prerequisite skills.

Understand Phase Evaluation Rubric

	Excellent	Good	Fair	Poor
Understand: Chicken Coop Assignment	The assignment provides outstanding evidence that the student attempted to develop an understanding of the project and design challenge.	The assignment provides solid evidence that the student attempted to develop an understanding of the project and design challenge.	The assignment provides a minimal amount of evidence that the student attempted to develop an understanding of the project and design challenge.	The assignment provides no evidence that the student attempted to develop an understanding of the project and design challenge.
Collaboration & Participation	Exceptional effort was made by the student to deepen or clarify their understanding through discussion with others.	Reasonable effort was made by the student to deepen or clarify their understanding through discussion with others.	Minimal effort was made by the student to deepen or clarify their understanding through discussion with others.	No effort was made by the student to deepen or clarify their understanding through discussion with others.

Explore Phase Evaluation Rubric

	Excellent	Good	Fair	Poor
Deeper Inquiry	Exceptional effort was invested by the student to expand their understanding of the design challenge, the factors that shape the project, or the types and quality of prior solutions.	Substantial effort was made by the student to expand their understanding of the design challenge, the factors that shape the project, or the types and quality of prior solutions.	A minimal amount of effort was made by the student to expand their understanding of the design challenge, the factors that shape the project, or the types and quality of prior solutions.	No effort was made by the student to expand their understanding of the design challenge, the factors that shape the project, or the types and quality of prior solutions.
Explore: Develop a Knowledge Base Assignment	The assignment provides outstanding evidence of design exploration. The notes and sketches indicate an exceptional grasp of the project and the factors that will influence their own work.	The assignment provides solid evidence of design exploration. The notes and sketches indicate a sound grasp of the project and the factors that will influence their own work.	The assignment provides a minimal amount of evidence of design exploration. The notes and sketches indicate a limited grasp of the project and the factors that will influence their own work.	The assignment provides no evidence of design exploration.
Collaboration	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together. Exhibits exceptional leadership abilities in helping others develop a deeper understanding of the project and the factors that will influence their own work.	Usually listens to, shares with, and supports the efforts of others. Does not create conflict in the group. Helps team members develop a deeper understanding of the project and the factors that will influence their own work.	Sometimes listens to, shares with, and supports the efforts of others, but sometimes is not a good team member. Contributes little towards helping team members develop a deeper understanding of the project and the factors that will influence their own work.	Never listens to, shares with, and supports the efforts of others. Often is not a good team member.

Define Phase Evaluation Rubric

	Excellent	Good	Fair	Poor
Define: Design Criteria Worksheet Assignment	Exceptional effort was invested by the student to use the worksheet to expand their understanding of the design challenge, the factors that shape the project, or the types and quality of prior solutions.	Substantial effort was made by the student to use the worksheet to expand their under-standing of the design challenge, the factors that shape the project, or the types and quality of prior solutions.	A minimal amount of effort was made by the student to use the worksheet to expand their understanding of the design challenge, the factors that shape the project, or the types and quality of prior solutions.	No effort was made by the student to use the worksheet to expand their understanding of the design challenge, the factors that shape the project, or the types and quality of prior solutions.
Collaboration	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together. Exhibits exceptional leadership abilities in helping others identify the critical project design criteria.	Usually listens to, shares with, and supports the efforts of others. Does not create conflict in the group. Helps team members identify the critical project design criteria.	Sometimes listens to, shares with, and supports the efforts of others, but sometimes is not a good team member. Contributes little towards helping team identify the critical project design criteria.	Never listens to, shares with, and supports the efforts of others. Often is not a good team member.

Ideate Phase Evaluation Rubric

	Excellent	Good	Fair	Poor
Ideation	Exceptional effort was invested by the student to generate concepts or potential solutions. A variety of media was used to explore ideas.	Substantial effort was made by the student to generate concepts or potential solutions. A variety of media was used to explore ideas.	A minimal amount of effort was made by the student to generate concepts or potential solutions.	No effort was made by the student to generate concepts or potential solutions.
Ideate: Write a Project Brief Assignment	The project brief provides outstanding evidence that the student has explored multiple design solutions and understands what a project brief is and how to write one.	The project brief provides solid evidence that the student has explored multiple design solutions and understands what a project brief is and how to write one.	The project brief provides a minimal amount of evidence that the student has explored multiple design solutions and understands what a project brief is and how to write one.	The project brief provides no evidence that the student has explored multiple design solutions nor understands what a project brief is and how to write one.
Collaboration	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together. Exhibits exceptional leadership abilities in facilitating the creation and assessment of multiple ideas.	Usually listens to, shares with, and supports the efforts of others. Does not create conflict in the group. Helps team members generate and assess multiple ideas.	Sometimes listens to, shares with, and supports the efforts of others, but sometimes is not a good team member. Contributes little towards helping team members generate ideas.	Never listens to, shares with, and supports the efforts of others. Makes no contribution towards generating ideas.

Prototype Phase Evaluation Rubric

	Excellent	Good	Fair	Poor
Prototype Development and Testing	Exceptional effort was invested by the student to visualize and test physical models and/or virtual prototypes.	Substantial effort was made by the student to visualize and test physical models and/or virtual prototypes.	A minimal amount of effort was made by the student to visualize and test physical models and/or virtual prototypes.	No effort was made by the student to visualize and test physical models and/or virtual prototypes.
Prototype: Test Your Design Assignment	The assignment provides outstanding evidence that the student has documented and evaluated prototype(s) or considered possible changes or refinements.	The assignment provides solid evidence that the student has documented and evaluated prototype(s) or considered possible changes or refinements.	The assignment provides a minimal amount of evidence that the student has documented and evaluated prototype(s) or considered possible changes or refinements.	The assignment provides no evidence that the student has documented and evaluated prototype(s) or considered possible changes or refinements.
Collaboration	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together. Exhibits exceptional leadership abilities in facilitating the production and assessment of prototypes.	Usually listens to, shares with, and supports the efforts of others. Does not create conflict in the group. Helps team members develop and assess prototypes.	Sometimes listens to, shares with, and supports the efforts of others, but sometimes is not a good team member. Contributes little towards developing or assessing prototypes.	Never listens to, shares with, and supports the efforts of others. Often is not a good team member.

Refine Phase Evaluation Rubric

	Excellent	Good	Fair	Poor
Refine Solutions	Exceptional effort was invested by the student to refine ideas. Proposed solutions are very closely aligned to the critical design criteria.	Substantial effort was made by the student to refine ideas. Proposed solutions are aligned to the critical design criteria.	A minimal amount of effort was made by the student to refine ideas. Proposed solutions somewhat aligned with the critical design criteria.	No effort was made by the student to refine ideas. Proposed solutions do not relate to the critical design criteria.
Refine: It's all in the details! Assignment	The assignment provides outstanding evidence that the student has significantly enhanced the design through the use of the software and created a design that meets the audience's needs.	The assignment provides solid evidence that the student has refined aspects of the design through the use of the software and created a design that meets the audience's needs.	The assignment provides a minimal amount of evidence that the student has refined aspects of the design through the use of the software and created a design that meets the audience's needs.	The assignment provides no evidence that the student has refined aspects of the design through the use of the software and created a design that meets the audience's needs.
Collaboration	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together. Exhibits exceptional leadership abilities in facilitating the refinement of ideas and details.	Usually listens to, shares with, and supports the efforts of others. Does not create conflict in the group. Helps team members refine their original ideas.	Sometimes listens to, shares with, and supports the efforts of others, but sometimes is not a good team member. Contributes little towards refining designs.	Never listens to, shares with, and supports the efforts of others. Has made no attempt to help refine designs.

Solution Phase Evaluation Rubric

	Excellent	Good	Fair	Poor
Preparation of Presentation	Exceptional effort was invested by the student to develop a high-quality final presentation.	Substantial effort was made by the student to organize and prepare all aspects of the final presentation.	A minimal amount of effort was made by the student prepare the final presentation.	No effort was made by the student to prepare the final presentation.
Communication and Team Dynamics	Exceptional effort was made to help the team conduct the final presentation. The quality of the verbal and visual elements of the presentation was outstanding.	Substantial effort was made to help the team conduct the final presentation. The quality of the verbal and visual elements of the presentation was good.	Minimal effort was made to help the team conduct the final presentation. The verbal and visual elements of the presentation were of mediocre quality.	No effort was made to help the team conduct the final presentation.
Solution: What did you learn? Assignment	The assignment provides outstanding evidence that the student has used Design Thinking to create their design and learned fundamental software and STEAM concepts by doing so.	The assignment provides solid evidence that the student has used Design Thinking to create their design and learned fundamental software and STEAM concepts by doing so.	The assignment provides a minimal amount of evidence that the student has used Design Thinking to create their design and learned fundamental software and STEAM concepts by doing so.	The assignment provides no evidence that the student has used Design Thinking to create their design and learned fundamental software and STEAM concepts by doing so.
Presentation Content	Exceptional effort was invested towards developing and presenting a quality design solution that is aligned to the design criteria for the project.	Substantial effort was invested towards developing and presenting a quality design solution that is aligned to the design criteria for the project.	Minimal effort was invested towards developing and presenting a quality design solution that is aligned to the design criteria for the project.	No effort was invested towards developing and presenting a quality design solution that is aligned to the design criteria for the project.

Project-based Learning: Creativity and Innovation Rubric

	Skills	Below Expectations	Meets Expectations	Exceeds Expectations
Critical Thinking	Student should use various types of reasoning (inductive, deductive, etc.), make sound judgments and decisions, and solve problems in both conventional and innovative ways.	Follows directions without understanding the purpose. Does not process information to develop new ideas for project or topic.	Demonstrates an understanding of the design challenge and is able to identify and ask significant questions. Problems are solved with an understanding of project goals and parameters.	A rich understanding is demonstrated by the ability to effectively communicate and demonstrate sound reasoning. Connective comprehension of project is shown by informed analysis. Problems are solved with logic and reflection. Intuitive leaps are made.
Communication	Student should be able to articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a diverse environment. Student should demonstrate effective listening and ability to decipher meaning.	Communication is limited to responses only. Engagement with others is limited in range.	Communication is effective and demonstrates an understanding of other's intent. Is able to use various forms of communication, such as multi-media and technologies.	Communication skills are superior and demonstrate effective listening and comprehension in a diverse environment. Communication goals are clear and informed and reflected in style and methods.
Creativity	Student demonstrates a willingness to take chances with design options. Student creation process shows tenacity and resourcefulness and uses a wide range of idea creation techniques.	Ideas are limited to project example. Does minimal brainstorming of new and worthwhile ideas. Project completion needs further work.	Creates some original ideas that might be better developed. Shows some imagination but may stay within conventional boundaries. Project creation is done with efficiency.	Understands the ideation process and demonstrates with informed results. Shows imagination and ingenuity by moving outside of expected parameters. Project steps are done with confidence and skill.

Project-based Learning: Creativity and Innovation Rubric

	Skills	Below Expectations	Meets Expectations	Exceeds Expectations
Collaboration	Student is able to work effectively and respectfully with diverse teams. Student should be able to exercise flexibility and willingness to make necessary compromises to accomplish a common goal.	Collaboration is limited. Might not consider others' input. Demonstrates a lack of interest in active participation and might only follow directions without understanding the purpose.	Is able to work in a team and incorporates feedback and input from others effectively. Is respectful and flexible in team situations.	Collaboration skills are solid and initiative is taken in improving team goals with sensitive and informed choices. Understands the strengths of team members and actively seeks to support overarching team goals above and beyond student's personal motives.
Innovation	Student's final design should demonstrate a creative understanding of the design challenge. Student should be able to present ideas that demonstrate an innovative approach to future solutions.	Solution is limited to project example. Solution might lack inspiration or conviction and demonstrate little understanding of project goal or target audience. Demonstrates difficulty in discussing solution.	Solution exhibits student thought and consideration. Potential innovation might be present without being entirely original or might need more time in ideation and refinement. Is able to field questions about solution option.	Solution exhibits original, innovative thought and consideration. Is able to present solution effectively with sound reasoning and creative leaps of understanding. Is able to field questions with informed confidence about solution. Risks are taken in new ideas.

Academic Standards

Key

- √ *denotes a correlation in ideas and concepts in both standard and lessons*
- X *denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities*
- ○ *denotes an implied idea or concept that may be used in both lesson and activity*

Common Core Standards for Mathematics Grades 9-12 Matrix

Grade 6	
Ratios and Proportional Relationships	
Understand ratio concepts and use ratio reasoning to solve problems.	○
The Number System	
Apply and extend previous understandings of multiplication and division to divide fractions by fractions.	○
Compute fluently with multi-digit numbers and find common factors and multiples.	○
Apply and extend previous understandings of numbers to the system of rational numbers.	○
Expressions and Equations	
Apply and extend previous understandings of arithmetic to algebraic expressions.	○
Reason about and solve one-variable equations and inequalities.	○
Represent and analyze quantitative relationships between dependent and independent variables.	○

Geometry	
Solve real-world and mathematical problems involving area, surface area, and volume.	√
Statistics and Probability	
Develop understanding of statistical variability.	
Summarize and describe distributions.	
Grade 7	
Ratios and Proportional Relationships	
Analyze proportional relationships and use them to solve real-world and mathematical problems.	○
The Number System	
Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.	○
Expressions and Equations	
Use properties of operations to generate equivalent expressions.	x
Solve real-life and mathematical problems	○
Geometry	
Draw, construct and describe geometrical figures and describe the relationships between them.	x
Solve real-life and mathematical problems	○
Statistics and Probability	
Use random sampling to draw inferences about a population.	
Draw Informal comparative Inferences about two populations.	
Investigate chance processes and develop, use, and evaluate probability models.	

Grade 8	
The Number System	
Know that there are numbers that are not rational, and approximate them by rational numbers.	o
Expressions and Equations	
Work with radicals and integer exponents.	o
Understand the connections between proportional relationships, lines, and linear equations.	x
Analyze and solve linear equations and pairs of simultaneous linear equations.	o
Functions	
Define, evaluate, and compare functions.	x
Use functions to model relationships between quantities.	x
Geometry	
Understand congruence and similarity using physical models, transparencies, or geometry software.	√
Understand and apply the Pythagorean Theorem.	o
Solve real-world and mathematical problems involving volume of cylinders, cones and spheres.	x
Statistics and Probability	
Investigate patterns of association in bivariate data.	

High School Mathematics

Number and Quantity	
The Real Number System	
Extend the properties of exponents to rational exponents	
Use properties of rational and irrational numbers.	○
Quantities	
Reason quantitatively and use units to solve problems	○
The Complex Number System	
Perform arithmetic operations with complex numbers	
Represent complex numbers and their operations on the complex plane	
Use complex numbers in polynomial identities and equations	
Vector and Matrix Quantities	
Represent and model with vector quantities.	
Perform operations on vectors.	
Perform operations on matrices and use matrices in applications.	
Algebra	
Seeing Structure In Expressions	
Interpret the structure of expressions	○
Write expressions in equivalent forms to solve problems	○
Arithmetic with Polynomials and Rational Expressions	
Perform arithmetic operations on polynomials	○
Understand the relationship between zeros and factors of polynomials	○
Use polynomial identities to solve problems	○

Rewrite rational expressions	o
Creating Equations	
Create equations that describe numbers or relationships	X
Reasoning with Equations and Inequalities	
Understand solving equations as a process of reasoning and explain the reasoning	o
Solve equations and inequalities in one variable	o
Solve systems of equations	o
Represent and solve equations and inequalities graphically	o
Functions	
Interpreting Functions	
Understand the concept of a function and use function notation	o
Interpret functions that arise in applications in terms of the context	o
Analyze functions using different representations	o
Building Functions	o
Build a function that models a relationship between two quantities	
Build new functions from existing functions	
Linear, Quadratic, and Exponential Models	
Construct and compare linear, quadratic, and exponential models and solve problems	o
Interpret expressions for functions in terms of the situation they model	o
Trigonometric Functions	
Extend the domain of trigonometric functions using the unit circle	o

Model periodic phenomena with trigonometric functions	
Prove and apply trigonometric identities	
Geometry	
Congruence	
Experiment with transformations in the plane	○
Understand congruence in terms of rigid motions	○
Prove geometric theorems	
Make geometric constructions	○
Similarity, Right Triangles, and Trigonometry	
Understand similarity in terms of similarity transformations	○
Prove theorems involving similarity	
Define trigonometric ratios and solve problems involving right triangles	○
Apply trigonometry to general triangles	○
Circles	
Understand and apply theorems about circles	○
Find arc lengths and areas of sectors of circles	○
Expressing Geometric Properties with Equations	
Translate between the geometric description and the equation for a conic section	○
Use coordinates to prove simple geometric theorems algebraically	
Geometric Measurement and Dimension	
Explain volume formulas and use them to solve problems	○

Visualize relationships between two dimensional and three-dimensional objects	○
Modeling with Geometry	
Apply geometric concepts in modeling situations	○
Statistics and Probability	
Interpreting Categorical and Quantitative Data	
Summarize, represent, and interpret data on a single count or measurement variable	
Summarize, represent, and interpret data on two categorical and quantitative variables	
Interpret linear models	○
Making Inferences and Justifying Conclusions	
Understand and evaluate random processes underlying statistical experiments	
Make inferences and justify conclusions from sample surveys, experiments and observational studies	○
Conditional Probability and the Rules of Probability	
Understand independence and conditional probability and use them to interpret data	
Use the rules of probability to compute probabilities of compound events in a uniform probability model	
Using Probability to Make Decisions	
Calculate expected values and use them to solve problems	
Use probability to evaluate outcomes of decisions	

Algebra I

Unit 1 - Relationships Between Quantities and Reasoning with Equations	
Reason quantitatively and use units to solve problems.	○
Interpret the structure of expressions.	
Understand solving equations as a process of reasoning and explain the reasoning.	○
Create equations that describe numbers or relationships	○
Solve equations and inequalities in one variable.	○
Unit 2 - Linear and Exponential Relationships	
Extend the properties of exponents to rational exponents.	
Solve systems of equations	○
Represent and solve equations and inequalities graphically	○
Understand the concept of a function and use function notation.	○
Interpret functions that arise in applications in terms of a context.	○
Analyze functions using different representations	○
Build a function that models a relationship between two quantities	○
Build new functions from existing functions.	○
Construct and compare linear, quadratic, and exponential models and solve problems.	○
Interpret expressions for functions in terms of the situation they model.	○
Unit 3 - Descriptive Statistics	
Summarize, represent, and interpret data on a single count or measurement variable.	
Summarize, represent, and interpret data on two categorical and quantitative variables.	

Interpret linear models.	
Unit 4 - Expressions and Equations	
Interpret the structure of expressions.	
Write expressions in equivalent forms to solve problems.	○
Perform arithmetic operations on polynomials.	○
Create equations that describe numbers or relationships.	○
Solve equations and inequalities in one variable.	○
Solve systems of equations.	○
Unit 5 - Quadratic Functions and Modeling	
Use properties of rational and irrational numbers.	
Interpret functions that arise in applications in terms of a context.	○
Analyze functions using different representations	○
Build a function that models a relationship between two quantities.	○
Build new functions from existing functions.	
Construct and compare linear, quadratic, and exponential models and solve problems.	○
Geometry	
Unit 1 – Congruence, Proof, and Constructions	
Experiment with transformations in the plane.	○
Understand congruence in terms of rigid motions.	○
Prove geometric theorems.	○
Make geometric constructions.	√

Unit 2 – Similarity, Proof, and Trigonometry	
Understand similarity in terms of similarity transformations	o
Prove theorems involving similarity	
Define trigonometric ratios and solve problems involving right triangles	o
Apply geometric concepts in modeling situations	√
Apply trigonometry to general triangles	x
Unit 3 - Extending to Three Dimensions	
Explain volume formulas and use them to solve problems	x
Visualize the relation between two-dimensional and three-dimensional objects	√
Apply geometric concepts in modeling situations	x
Unit 4 - Connecting Algebra and Geometry through Coordinates	
Use coordinates to prove simple geometric theorems algebraically	o
Translate between the geometric description and the equation for a conic section	
Unit 5 - Circles With and Without Coordinates	
Understand and apply theorems about circles.	
Find arc lengths and areas of sectors of circles	
Translate between the geometric description and the equation for a conic section	
Use coordinates to prove simple geometric theorem algebraically.	
Apply geometric concepts in modeling situations	
Unit 6 - Applications of Probability	
Understand independence and conditional probability and use them to interpret data.	

Use the rules of probability to compute probabilities of compound events in a uniform probability model	
Use probability to evaluate outcomes of decisions.	
Algebra II	
Unit 1 - Polynomial, Rational, and Radical Relationships	
Perform arithmetic operations with complex numbers.	
Use complex numbers in polynomial identities and equations.	
Interpret the structure of expressions.	
Write expressions in equivalent forms to solve problems.	
Perform arithmetic operations on polynomials.	
Understand the relationship between zeros and factors of polynomial	
Use polynomial identities to solve problems.	
Rewrite rational expressions.	
Understand solving equations as a process of reasoning and explain the reasoning.	
Represent and solve equations and inequalities graphically.	
Analyze functions using different representations.	
Unit 2 - Trigonometric Functions	
Extend the domain of trigonometric functions using the unit circle.	
Model periodic phenomena with trigonometric function.	
Prove and apply trigonometric identities.	
Unit 3 - Modeling with Functions	
Create equations that describe numbers or relationships.	

Interpret functions that arise in applications in terms of a context.	
Analyze functions using different representations.	
Build a function that models a relationship between two quantities.	
Build new functions from existing functions.	○
Construct and compare linear, quadratic, and exponential models and solve problems.	○
Unit 4 - Inferences and Conclusions from Data	
Summarize, represent, and interpret data on single count or measurement variable.	
Understand and evaluate random processes underlying statistical experiments.	
Make inferences and justify conclusions from sample surveys, experiments and observational studies.	○
Use probability to evaluate outcomes of decisions.	

Comparison of Common Core Standards for Mathematics and the Autodesk® Digital STEAM Workshop

Source: Common Core Standards for Mathematics

Common Core Standards for English Language Arts Grades 9-12 Matrix

College and Career Readiness Anchor Standards for Reading Grades 6-12	
Key Ideas and Details	
Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	○
Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and Ideas.	
Analyze how and why individuals, events, and ideas develop and interact over the course of a text.	
Craft and Structure	
Interpret words and phrases as they are used in Il text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.	○
Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.	
Assess how point of view or purpose shapes the content and style of a text.	
Integration of Knowledge and Ideas	
Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.	√
Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.	
Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.	

Range of Reading and Level of Text Complexity	
Read and comprehend complex literary and informational texts independently and proficiently.	x
College and Career Readiness Anchor Standards for Writing Grades 6-12	
Text Types and Purposes	
Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	○
Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.	○
Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.	
Production and Distribution of Writing	
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	○
Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.	○
Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.	○
Research to Build and Present Knowledge	
Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.	√
Gather relevant Information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.	√
Draw evidence from literary or informational texts to support analysis, reflection, and research.	x

Range of Writing	
Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	x
College and Career Readiness Anchor Standards for Speaking and Listening Grades 6-12	
Comprehension and Collaboration	
Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	√
Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.	○
Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.	
Presentation of Knowledge and Ideas	
Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.	√
Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.	√
Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.	○
College and Career Readiness Anchor Standards for Language Grades 6-12	
Conventions of Standard English	
Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.	○
Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.	○

Knowledge of Language	
Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.	○
Vocabulary Acquisition and Use	
Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.	○
Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.	
Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase Important to comprehension or expression.	X

Comparison of Common Core Standards for English Language Arts and Literacy in History/Social Studies, Science and Technical Subjects and the Autodesk® Digital STEAM Workshop

Source: Common Core Standards for English Language Arts and Literacy in History/Social Studies, Science and Technical Subjects

NGSS Next Generation Science Standards Grades 9-12 Matrix

HS. Chemical Reactions	
HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	○
HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction systemdepends upon the changes in total bond energy.	
HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.	○
HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*	
HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	
HS. Forces and Interactions	
HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	
HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.	
HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*	
HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.	
HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce	

HS. Energy	
HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known	
HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.	
HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*	○
HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).	
HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	
HS. Waves and Electromagnetic Radiation	
HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wave length, and speed of waves traveling in various media	
HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.	
HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	
HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	
HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*	

HS. Structure and Function	
HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.	○
HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.	
HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis	
HS. Matter and Energy in Organisms and Ecosystems	
HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.	
HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	
HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.	√
HS-LS2-4. Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	√
HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	
HS. Interdependent Relationships in Ecosystems	
HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales	
HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.	○

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.	√
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*	√
HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce	√
HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*	x
HS. Inheritance and Variation of Traits	
HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms	
HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.	x
HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.	x
HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.	
HS. Natural Selection and Evolution	
HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence	x
HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.	x
HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait	

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.	○
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	X
HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.	
HS. Space Systems	
HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.	
HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.	
]HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	
HS.History of Earth	
HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks	
HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.	
HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	
HS. Earth's Systems	
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	○
HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.	

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.	
HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	
HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth systems and life on Earth.	
HS. Weather and Climate	
HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth systems result in changes in climate.	○
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	○
HS. Human Impacts	
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	○
HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*	
HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*	
HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.*	
HS. Engineering Design	
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	
HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	

NGSS are based on the NRC Framework for K–12 Science Educatio

ITEA Standards for Technological Literacy Matrix

	STL Standard 1: Students will develop an understanding of the characteristics and scope of technology.	
K-2	A. The natural world and human-made world are different.	
	B. All people use tools and techniques to help them do things.	
3-5	C. Things that are found in nature differ from things that are human-made in how they are produced and used.	
	D. Tools, materials, and skills are used to make things and carry out tasks.	
	E. Creative thinking and economic and cultural influences shape technological development.	
6-8	F. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	√
	G. The development of technology is a human activity and is the result of individual or corporate needs and the ability to be creative.	√
	H. Technology is closely linked to creativity, which has resulted in innovation.	√
	I. Corporations can often create demand for a product by bringing it onto the market and advertising it.	○
9-12	J. The nature and development of technological knowledge and processes are functions of the setting.	√
	K. The rate of technological development and diffusion is increasing rapidly.	○
	L. Inventions and innovations are the results of specific, goal-directed research.	√
	M. Most development of technologies these days is driven by the profit motive and the market.	○
	TL Standard 2: Students will develop an understanding of the core concepts of technology.	
K-2	A. Some systems are found in nature, and some are made by humans.	○
	B. Systems have parts or components that work together to accomplish a goal.	○

	C. Tools are simple objects that help humans complete tasks.	○
	D. Different materials are used in making things.	○
	E. People plan in order to get things done.	○
3-5	F. A subsystem is a system that operates as a part of another system.	○
	G. When parts of a system are missing, it may not work as planned.	○
	H. Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.	○
	I. Tools are used to design, make, use, and assess technology.	○
	J. Materials have many different properties.	○
	K. Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.	○
	L. Requirements are the limits to designing or making a product or system.	○
6-8	M. Technological systems include input, processes, output, and, at times, feedback.	○
	N. Systems thinking involves considering how every part relates to others.	○
	O. An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.	○
	P. Technological systems can be connected to one another.	○
	Q. Malfunctions of any part of a system may affect the function and quality of the system.	○
	R. Requirements are the parameters placed on the development of a product or system.	√
	S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.	○
	T. Different technologies involve different sets of processes.	○
	U. Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.	○

	V. Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.	○
9-12	W. Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.	√
	X. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.	X
	Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.	○
	Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.	X
	AA. Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.	○
	BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.	√
	CC. New technologies create new processes.	X
	DD. Quality control is a planned process to ensure that a product, service, or system meets established criteria.	○
	EE. Management is the process of planning, organizing, and controlling work.	○
	FF. Complex systems have many layers of controls and feedback loops to provide information.	○
	STL Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	
K-2	A. The study of technology uses many of the same ideas and skills as other subjects.	○
3-5	B. Technologies are often combined.	
	C. Various relationships exist between technology and other fields of study.	
	D. Technological systems often interact with one another.	X

6-8	E. A product, system, or environment developed for one setting may be applied to another setting.	X
	F. Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.	X
9-12	G. Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.	X
	H. Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.	X
	I. Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge.	O
	J. Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology.	X
	STL Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.	
K-2	A. The use of tools and machines can be helpful or harmful.	O
3-5	B. When using technology, results can be good or bad.	O
	C. The use of technology can have unintended consequences.	O
6-8	D. The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology’s development and use.	O
	E. Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.	O
	F. The development and use of technology poses ethical issues.	O
	G. Economic, political, and cultural issues are influenced by the development and use of technology.	O
9-12	H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.	O
	I. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.	

	J. Ethical considerations are important in the development, selection, and use of technologies.	
	K. The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.	○
	STL Standard 5: Students will develop an understanding of the effects of technology on the environment.	
K-2	A. Some materials can be reused and/or recycled.	√
3-5	B. Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.	
	C. The use of technology affects the environment in good and bad ways.	
6-8	D. The management of waste produced by technological systems is an important societal issue.	X
	E. Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.	√
	F. Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.	X
9-12	G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.	X
	H. When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.	X
	I. With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making.	X
	J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.	X
	K. Humans devise technologies to reduce the negative consequences of other technologies.	○
	L. Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment.	X

	STL Standard 6: Students will develop an understanding of the role of society in the development and use of technology.	
K-2	A. Products are made to meet individual needs and wants.	x
3-5	B. Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.	√
	C. Individual, family, community, and economic concerns may expand or limit the development of technologies.	√
6-8	D. Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.	○
	E. The use of inventions and innovations has led to changes in society and the creation of new needs and wants.	x
	F. Social and cultural priorities and values are reflected in technological devices.	○
	G. Meeting societal expectations is the driving force behind the acceptance and use of products and systems.	○
9-12	H. Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.	
	I. The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.	○
	J. A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies.	○
	STL Standard 7: Students will develop an understanding of the influence of technology on history.	
K-2	A. The way people live and work has changed throughout history because of technology.	○
3-5	B. People made tools to provide food, to make clothing, and to protect themselves.	
6-8	C. Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements.	○

	D. The specialization of function has been at the heart of many technological improvements.	○
	E. The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.	○
	F. In the past, an invention or innovation was not usually developed with the knowledge of science.	○
6-8	G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.	○
	H. The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.	○
	I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.	
	J. Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.	
	K. The Iron Age was defined by the use of iron and steel as the primary materials for tools.	
	L. The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.	
	M. The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.	
	N. The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time.	
	O. The Information Age places emphasis on the processing and exchange of information.	
	STL Standard 8: Students will develop an understanding of the attributes of design.	
K-2	A. Everyone can design solutions to a problem.	
	B. Design is a creative process.	

3-5	C. The design process is a purposeful method of planning practical solutions to problems.	
	D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.	
6-8	E. Design is a creative planning process that leads to useful products and systems.	√
	F. There is no perfect design.	√
	G. Requirements for a design are made up of criteria and constraints	√
9-12	H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.	√
	I. Design problems are seldom presented in a clearly defined form.	√
	J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.	√
	K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.	√
	STL Standard 9: Students will develop an understanding of engineering design.	
K-2	A. Asking questions and making observations helps a person to figure out how things work.	√
	B. All products and systems are subject to failure. Many products and systems, however, can be fixed.	√
3-5	C. When designing an object, it is important to be creative and consider all ideas.	√
	D. Models are used to communicate and test design ideas and processes.	√
6-8	E. Design involves a set of steps, which can be performed in different sequences and repeated as needed.	√
	F. Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.	√

	G. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.	√
9-12	H. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.	√
	I. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.	x
	J. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.	√
	K. The process of engineering design takes into account a number of factors.	√
	STL Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	
K-2	A. Asking questions and making observations helps a person to figure out how things work.	√
	B. All products and systems are subject to failure. Many products and systems, however, can be fixed.	√
3-5	C. Troubleshooting is a way of finding out why something does not work so that it can be fixed.	√
	D. Invention and innovation are creative ways to turn ideas into real things.	√
	E. The process of experimentation, which is common in science, can also be used to solve technological problems.	√
6-8	F. Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	x
	G. Invention is a process of turning ideas and imagination into devices and systems.	√
	H. Some technological problems are best solved through experimentation.	√
9-12	I. Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	√
	J. Technological problems must be researched before they can be solved.	√

	K. Not all problems are technological, and not every problem can be solved using technology.	x
	L. Many technological problems require a multidisciplinary approach.	√
	STL Standard 11: Students will develop the abilities to apply the design process.	
K-2	A. Brainstorm people's needs and wants and pick some problem that can be solved through the design process.	√
	B. Build or construct an object using the design process.	√
	C. Investigate how things are made and how they can be improved.	√
3-5	D. Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem.	√
	E. The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.	√
	F. Test and evaluate the solutions for the design problem.	√
	G. Improve the design solutions.	√
6-8	H. Apply a design process to solve problems in and beyond the laboratory-classroom.	√
	I. Specify criteria and constraints for the design.	√
	J. Make two-dimensional and three-dimensional representations of the designed solution.	√
	K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	√
	L. Make a product or system and document the solution.	√
9-12	M. Identify the design problem to solve and decide whether or not to address it.	√
	N. Identify criteria and constraints and determine how these will affect the design process.	√
	O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.	√

	P. Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.	√
	Q. Develop and produce a product or system using a design process.	√
	R. Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	√
	STL Standard 12: Students will develop the abilities to use and maintain technological products and systems.	
K-2	A. Discover how things work.	√
	B. Use hand tools correctly and safely and be able to name them correctly.	√
	C. Recognize and use everyday symbols.	√
3-5	D. Follow step-by-step directions to assemble a product.	√
	E. Select and safely use tools, products, and systems for specific tasks.	√
	F. Use computers to access and organize information.	√
	G. Use common symbols, such as numbers and words, to communicate key ideas.	√
6-8	H. Use information provided in manuals, protocols, or by experienced people to see and understand how things work.	o
	I. Use tools, materials, and machines safely to diagnose, adjust, and repair systems.	
	J. Use computers and calculators in various applications.	√
	K. Operate and maintain systems in order to achieve a given purpose.	o
9-12	L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.	x
	M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.	
	N. Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.	

	O. Operate systems so that they function in the way they were designed.	
	P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.	√
	STL Standard 13: Students will develop the abilities to assess the impact of products and systems.	
K-2	A. Collect information about everyday products and systems by asking questions.	√
	B. Determine if the human use of a product or system creates positive or negative results.	√
3-5	C. Compare, contrast, and classify collected information in order to identify patterns.	
	D. Investigate and assess the influence of a specific technology on the individual, family, community, and environment.	
	E. Examine the trade-offs of using a product or system and decide when it could be used.	
6-8	F. Design and use instruments to gather data.	
	G. Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology.	
	H. Identify trends and monitor potential consequences of technological development.	○
	I. Interpret and evaluate the accuracy of the information obtained and determine if it is useful.	○
9-12	J. Collect information and evaluate its quality.	○
	K. Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.	○
	L. Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology.	○
	M. Design forecasting to evaluate the results of altering natural systems.	○

	STL Standard 14: Students will develop an understanding of and be able to select and use medical technologies.	
K-2	A. Vaccinations protect people from getting certain diseases.	
	B. Medicine helps sick people get better.	
	C. There are many products designed specifically to help people take care of themselves.	
3-5	D. Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing.	
	E. Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility.	
	F. Many tools and devices have been designed to help provide clues about health and to provide a safe environment.	
6-8	G. Advances and innovations in medical technologies are used to improve healthcare.	
	H. Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety.	
	I. The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines are produced.	
	J. Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.	
9-12	K. Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.	
	L. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.	

	M. The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.	
	STL Standard 15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.	
K-2	A. The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources.	
	B. There are many different tools necessary to control and make up the parts of an ecosystem.	
3-5	C. Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals.	
	D. Most agricultural waste can be recycled.	
	E. Many processes used in agriculture require different procedures, products, or systems.	
6-8	F. Technological advances in agriculture directly affect the time and number of people required to produce food for a large population.	
	G. A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.	
	H. Biotechnology applies the principles of biology to create commercial products or processes.	
	I. Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment.	
	J. The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.	
9-12	K. Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.	
	L. Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.	

	M. Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.	
	N. The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.	
	STL Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.	
K-2	A. Energy comes in many forms.	○
	B. Energy should not be wasted.	○
3-5	C. Energy comes in different forms.	○
	D. Tools, machines, products, and systems use energy in order to do work.	○
6-8	E. Energy is the capacity to do work.	○
	F. Energy can be used to do work, using many processes.	○
	G. Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.	○
	H. Power systems are used to drive and provide propulsion to other technological products and systems.	
	I. Much of the energy used in our environment is not used efficiently.	X
9-12	J. Energy cannot be created or destroyed; however, it can be converted from one form to another.	○
	K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.	○
	L. It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings.	
	M. Energy resources can be renewable or nonrenewable.	○
	N. Power systems must have a source of energy, a process, and loads.	○

	STL Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.	
K-2	A. Information is data that has been organized.	√
	B. Technology enables people to communicate by sending and receiving information over a distance.	√
	C. People use symbols when they communicate by technology.	√
3-5	D. The processing of information through the use of technology can be used to help humans make decisions and solve problems.	√
	E. Information can be acquired and sent through a variety of technological sources, including print and electronic media.	√
	F. Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.	√
	G. Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.	√
6-8	H. Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.	○
	I. Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.	○
	J. The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.	○
	K. The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.	√
9-12	L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.	○
	M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.	○
	N. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.	○

	O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.	○
	P. There are many ways to communicate information, such as graphic and electronic means.	○
	Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.	○
	STL Standard 18: Students will develop an understanding of and be able to select and use transportation technologies.	
K-2	A. A transportation system has many parts that work together to help people travel.	
	B. Vehicles move people or goods from one place to another in water, air, or space and on land.	
	C. Transportation vehicles need to be cared for to prolong their use.	
3-5	D. The use of transportation allows people and goods to be moved from place to place.	
	E. A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working.	
6-8	F. Transporting people and goods involves a combination of individuals and vehicles.	○
	G. Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.	○
	H. Governmental regulations often influence the design and operation of transportation systems.	○
	I. Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.	○
9-12	J. Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	○

	K. Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.	○
	L. Transportation services and methods have led to a population that is regularly on the move.	○
	M. The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques.	○
	STL Standard 19: Students will develop an understanding of and be able to select and use manufacturing technologies.	
K-2	A. Manufacturing systems produce products in quantity.	
	B. Manufactured products are designed.	
3-5	C. Processing systems convert natural materials into products.	
	D. Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products.	
	E. Manufacturing enterprises exist because of a consumption of goods.	
6-8	F. Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them.	○
	G. Manufactured goods may be classified as durable or non-durable.	○
	H. The manufacturing process includes the designing, development, making, and servicing of products and systems.	○
	I. Chemical technologies are used to modify or alter chemical substances.	○
	J. Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining.	○
	K. Marketing a product involves informing the public about it as well as assisting in selling and distributing it.	○
9-12	L. Servicing keeps products in good operating condition.	○

	M. Materials have different qualities and may be classified as natural, synthetic, or mixed.	x
	N. Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.	o
	O. Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.	o
	P. The interchangeability of parts increases the effectiveness of manufacturing processes.	o
	Q. Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.	o
	R. Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it.	o
	STL Standard 20: Students will develop an understanding of and be able to select and use construction technologies.	
K-2	A. People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools.	√
	B. The type of structure determines how the parts are put together.	√
3-5	C. Modern communities are usually planned according to guidelines.	√
	D. Structures need to be maintained.	√
	E. Many systems are used in buildings.	√
6-8	F. The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.	√
	G. Structures rest on a foundation.	√
	H. Some structures are temporary, while others are permanent.	√
	I. Buildings generally contain a variety of subsystems.	√
9-12	J. Infrastructure is the underlying base or basic framework of a system.	o

K. Structures are constructed using a variety of processes and procedures.	○
L. The design of structures includes a number of requirements.	√
M. Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.	x
N. Structures can include prefabricated materials.	x

Comparison of Standards for Technological Literacy (STL) and the Autodesk® Digital STEAM Workshop

Source: International Technology Education Association's (ITEA) Standards for Technological Literacy: Content for the Study of Technology.

National Standards for Visual Art Grades 9-12 Matrix

#1: Understanding and applying media, techniques, and processes	
Students apply media, techniques, and processes with sufficient skill, confidence, and sensitivity that their intentions are carried out in their artworks – (proficient)	○
Students conceive and create works of visual art that demonstrate an understanding of how the communication of their ideas relates to the media, techniques, and processes they use – (proficient)	○
Students communicate ideas regularly at a high level of effectiveness in at least one visual arts medium – (advanced)	○
Students initiate, define, and solve challenging visual arts problems independently using intellectual skills such as analysis, synthesis, and evaluation – (advanced)	○
#2: Using knowledge of structures and functions	
Students demonstrate the ability to form and defend judgments about the characteristics and structures to accomplish commercial, personal, communal, or other purposes of art – (proficient)	○
Students evaluate the effectiveness of artworks in terms of organizational structures and functions – (proficient)	
Students create artworks that use organizational principles and functions to solve specific visual arts problems – (proficient)	
Students demonstrate the ability to compare two or more perspectives about the use of organizational principles and functions in artwork and to defend personal evaluations of these perspectives – (Advanced)	
Students create multiple solutions to specific visual arts problems that demonstrate competence in producing effective relationships between structural choices and artistic functions – (Advanced)	
#3: Choosing and evaluating a range of subject matter, symbols, and ideas	
Students reflect on how artworks differ visually, spatially, temporally, and functionally, and describe how these are related to history and culture – (proficient)	

Students apply subjects, symbols, and ideas in their artworks and use the skills gained to solve problems in daily life – (proficient)	○
Students describe the origins of specific images and ideas and explain why they are of value in their artwork and in the work of others – (Advanced)	
Students evaluate and defend the validity of sources for content and the manner in which subject matter, symbols, and images are used in the students' works and in significant works by others – (Advanced)	
#4: Understanding the visual arts in relation to history and cultures	
Students differentiate among a variety of historical and cultural contexts in terms of characteristics and purposes of works of art – (proficient)	
Students describe the function and explore the meaning of specific art objects within varied cultures, times, and places – (proficient)	
Students analyze relationships of works of art to one another in terms of history, aesthetics, and culture, justifying conclusions made in the analysis and using such conclusions to inform their own art making – (proficient)	
Students analyze and interpret artworks for relationships among form, context, purposes, and critical models, showing understanding of the work of critics, historians, aestheticians, and artists – (Advanced)	
Students analyze common characteristics of visual arts evident across time and among cultural/ethnic groups to formulate analyses, evaluations, and interpretations of meaning – (Advanced)	
#5: Reflecting upon and assessing the characteristics and merits of their work and the work of others	
Students identify intentions of those creating artworks, explore the implications of various purposes, and justify their analyses of purposes in particular works – (proficient)	
Students describe meanings of artworks by analyzing how specific works are created and how they relate to historical and cultural contexts – (proficient)	
Students reflect analytically on various interpretations as a means for understanding and evaluating works of visual art – (proficient)	
Students correlate responses to works of visual art with various techniques for communicating meanings, ideas, attitudes, views, and intentions – (Advanced)	○

#6: Making connections between visual arts and other disciplines	
Students compare the materials, technologies, media, and processes of the visual arts with those of other arts disciplines as they are used in creation and types of analysis – (proficient)	√
Students compare characteristics of visual arts within a particular historical period or style with ideas, issues, or themes in the humanities or sciences – (proficient)	
Students synthesize the creative and analytical principles and techniques of the visual arts and selected other arts disciplines, the humanities, or the sciences – (Advanced)	x

Comparison of National Standards for Visual Arts Grade 9-12 and Autodesk® Digital STEAM Workshop

Source: National Standards for Visual Arts developed by a consortium of National Arts Education Associations and the National Standards for Arts Education