Facilitation Guide: Shrink-O-Matic

Challenge

Understanding scale and object sizes is an important component of manufacturing everything from tools to vehicles. Students will examine the complex relationships between size, scale, and manufacturing processes by creating two versions of a Glowforge Catalog design—one full size and one scaled version— while maintaining its quality and effectiveness.

Rationale

Scaling a piece or entire product allows manufacturers to observe and test large designs without creating full-scale versions and potentially wasting materials or capital.

Scaling products is also helpful when designing products for specific people or needs. Think about going to the hardware store or the tool chest in the workshop. You may look through the aisles or drawers for the right Allen wrench or ratchet socket to construct your project. Without having the specific size for your hardware, your tool won't fit properly and you'll be left attaching pieces by hand, an insufficient and ineffective solution. Instead, using scaled tools, you're able to use the right 3/8" Allen wrench or 6mm socket for your project and can quickly and properly complete the task at hand.

Just as William G. Allen and J.J. Richardson scaled their wrench designs in the past, students will manufacture, test, and refine a scaled version of a product or design. For this challenge, they will focus on creating a scaled design while maintaining, or even improving, its functionality.

Manufacturers are increasingly using 2D and 3D print technology to develop innovative solutions for consumer needs. Glowforge is the ideal tool for manufacturing scaled products. Its ability to cut, engrave, and score a range of materials into full products or individual product components makes it an ideal for versatile design and proportional scaling.

In addition to prototyping scaled designs, students can apply the same skills to manufacture other marketable scaled products. Toy cars, doll houses, kitchen sets, and Dungeons and Dragons figures are all items that have been manufactured as full size products and then scaled into miniature models for customers. The manufacturers and makers behind miniatures commonly use a 1/2, 1/12, or 1/24 scale to maintain proportions of the original item in its new, smaller version. This allows manufacturers, hobbyists, and skilled full-time miniaturists to

shrink down large items like an airplane or double-decker bus into an object that can sit on a desk or bedroom shelf.
Glowforge is an innovative tool that allows students to scale designs with ease. The Glowforge App provides an intuitive interface that is easy for students to use, helping them to develop valuable manufacturing and design skills that can be applied in a range of contexts.

Standards

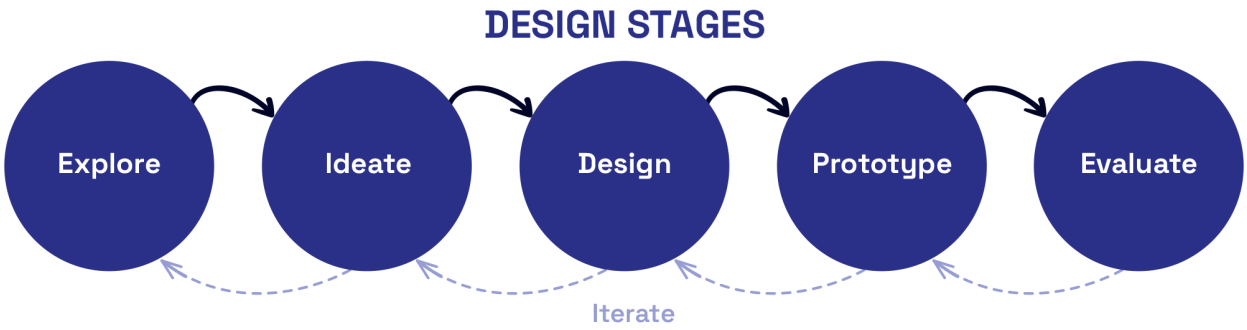
Common Career Technical Core Standards

- MN-PPD 1 Produce quality products that meet manufacturing standards and exceed customer satisfaction.
- MN-PPD 2 Research, design and implement alternative manufacturing processes to manage production of new and/or improved products.
- MN-QA 4.5 Inspect the product to verify that it meets specifications.
- MN 6.2 Summarize how materials can be processed using tools and machines.
- MN 6.5 Explain the processes of inspection and quality control used in manufacturing.

ISTE Standards for Students

- Knowledge Constructor 1.3 d Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
- Innovative Designer 1.4 Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

Facilitation Steps to Support the Design Process



Explore

In this section, students will focus on researching and investigating the concepts of proportion and scale as well as techniques for scaling on Glowforge. To ensure that students have the knowledge and skills they need to complete this stage, use the following steps:

1. Consider curating a selection of Glowforge Catalog designs for the students to select from. You can use the following to get started:
    - Nomad Wagon
    - Mechanical Marble Run Game
    - Helicopter
    - Robot
    - Calendar
    - Double-decker bus
2. Provide students with question prompts from the Explore stage of the challenge to inspire their research and help them consider concepts of scaled designs.
3. Explore the Scale Designs Precisely article for an introduction to scaling designs in the Glowforge App.
4. Research and collect any manufacturing requirements or specifications that your students can use to perform a quality inspection of their scaled designs.
5. Ask students to share their findings and discuss what they learned during the Explore stage.
    - Encourage students to share both in small and large groups. If students are working in groups to complete this design challenge, have different groups partner together to discuss what they discovered.
6. Determine if there are specific scaling guidelines that you would like students to follow. This could mean selecting a scale ratio or narrowing the design options available in the Ideate stage. Consider reviewing this article about techniques for scaling designs.
    - For workshop tools: create versions that are in 1/16" or millimeter increments
    - For making everyday objects smaller: use 1/2, 1/12 or 1/24 ratio

At the end of this stage, students will reflect on the research they did to learn more about manufacturing and scaling techniques. Encourage them to consider if there are any catalog designs that inspired them.

Before moving on, students should consider if there are any other resources or techniques that would be helpful to explore. Once they are finished, students will continue to the Ideate stage where they will brainstorm which design options and techniques they will use for scaling their product.

Ideate

This stage allows students to explore as many ideas as possible without judgment. Remind students to explore their interests and the Glowforge Catalog for other inspirations. To ensure

that students have the knowledge and skills they need to complete this stage, use the following steps:

1. Provide students with question prompts from the Ideate stage of the challenge to help them brainstorm.
2. Encourage students to brainstorm ideas using one or more methods.
    - Allow students to brainstorm individually or in small groups to utilize multiple perspectives.
    - Provide students with different ideation strategies to help them begin.

At the end of this stage, students should have generated multiple ideas for their scaled designs and should be able to narrow their focus in order to develop a proportional, functioning design.

Before moving on, students should consider which manufacturing or design techniques they will use and what ratio they will use to scale their design. Then in the next stage, students will select one or two ideas to develop further.

Design

In this stage, students will develop their ideas and draft a detailed plan for their scaled design. Students should focus on one or two ideas to better understand their final design before printing. Remind students to consider any moving parts in the design as joinery can present challenges when scaling. To ensure that students have the knowledge and skills they need to complete this stage, use the following steps:

1. Use question prompts from the Design stage to help them design.
2. Introduce, review, or model available design software options, including the Glowforge App.
    - Assist students as they create sketches or digital mockup of their scaled design. Consider having students use CAD software like SketchUp or AutoCAD to create detailed 2D and 3D designs.
    - Review Glowforge safety guidelines.
    - Use this video to demonstrate how to use Glowforge.
    - Remind students of any applicable classroom or school policies.
    - Review the Glowforge Community Forum or page 25 in the Glowforge Educator Guide for tips and tricks for scaling designs.
    - Review Glowforge Community Forum and Joinery: Joints for Laser Cut Assemblies article for additional joinery ideas and techniques.

At the end of this stage, students will have a detailed plan for their scaled design, including sketches or digital mockups, as well as some ideas for resolving any joinery issues that may arise.

Before moving on, students should consider if they would like to revisit their design further to change anything. Once they are finished, students will continue to the Prototype stage where they will select and test one of their fully developed design plans.

Prototype

In this stage, students will use their design plan to create two prototypes: one full size and one scaled version. Students will select one of their fully developed design plans, print necessary elements on Glowforge, and test their products to ensure they meet manufacturing quality control standards and scale proportionally. To ensure that students have the knowledge and skills they need to complete this stage, use the following steps:

1. Demonstrate how to use Glowforge in a safe and efficient manner.
    - Review the Glowforge safety guidelines.
    - Remind students of any applicable classroom or school policies.
    - Use this video to demonstrate how to use Glowforge.
2. Consider modeling a quality assurance check on an item in the classroom. This will help students apply the skills as they inspect their own products.
3. Provide students with question prompts from the Prototype stage of the challenge to help them develop their prototypes.
4. Give students the time and resources needed to produce the Glowforge elements of their design, assemble their pieces, and test the elements of their prototypes.
    - Provide students with access to your Glowforge using a classroom print schedule to ensure that all students are able to produce the elements they need efficiently.

At the end of this stage, students will have two finished prototypes that are scaled proportionally and function as intended. Students should perform a quality assurance inspection of their finished prints to ensure they meet manufacturing specifications. Students may need to test multiple times or return to earlier stages of the design process before moving on. Once finished, students will continue to the Evaluate stage where they will receive feedback on their finished prototypes.

Evaluate

In this stage, students will evaluate their designs and receive feedback from others. Feedback can be provided in pairs, small groups, or as a whole class. Encourage students to reflect on their process and consider their alignment to their original intent and manufacturing specifications. To ensure that students have the knowledge and skills they need to complete this stage, use the following steps:

1. Provide students with question prompts from the Evaluate stage of the challenge to help them reflect on their scaled design.
2. Encourage students to share and discuss their ideas to generate feedback and suggestions from their peers to refine and enhance their scaled design.
    - Students can use the question prompts from the Evaluate stage to guide their discussions.
    - Use a peer feedback model, such as a gallery walk, to support students as they work in pairs, small groups, or as a whole class.
3. Provide students with question prompts to help them reflect on the feedback that they received. These might include:

- How can you further improve and refine your scaled design?
- If making additional changes to your design, which of the design process stages will you return to?

4. If applicable, provide students with time to complete a learning reflection, self-assessment, and/or peer critique.
    - Use the provided Assessment Suggestions for more ideas.

At the end of this stage, students will be able to reflect on the strengths and areas for improvement of their scaled design. Students should determine whether adjustments are needed and return to the appropriate stage in the design process to modify their design. Consider assessing student work using one of the Assessment Suggestions or extending the challenge using provided Extension Activities.

Supplemental Supports

- For newer Glowforge users, demonstrate how to use your Glowforge and its design features, including the design software, engraving capabilities, and cutting functionality. Check out the Glowforge Educator Guide for more ideas.
- Working at scale can be daunting at first. For a scaling refresh, review this lesson from Khan Academy or this video explanations for using a scale ruler.

Assessment Suggestions

Overall Learning Reflection

Learning reflections allow students to reflect on their learning experiences, identify key concepts, and explain how they have grown throughout the design process. Ask students to write or record a video about what they learned during the challenge. Students can incorporate feedback elements from the Evaluate stage to describe their strengths and areas for improvement.

Self-Assessment

Self-assessments allow students to reflect on their learning through portfolios, presentations, or learning journals that involve evaluating their own progress and identifying areas for improvement. Consider providing criteria to students prior to beginning the challenge that can be used by the student to reflect on their progress throughout the challenge. The criteria may include:

- Scale and function: How well did I scale my design while maintaining its functionality and proper proportions?
- Use of digital tools: How well did I use digital tools to aid my design?
- Manufacturing specifications: Did I meet all of the manufacturing specifications?
- Use of the design process: How well did I develop, test, and refine prototypes as part of a cyclical design and quality assurance process?

Educator or Peer Assessment

Educator or peer assessments allow educators or students to review the quality and effectiveness of the scaled design. The assessment can be based on specific criteria, such as the use of scaling or joinery techniques, or a more open approach like a gallery walk. Some criteria to consider may include:

- Scale: Did the design proportionally scale as intended?
- Function: Did the design move or function as originally planned?
- Design: Did the scaled product effectively utilize design software features?
- Manufacturing specifications: Did the design meet or exceed all manufacturing specifications?

Extension Activities

Design challenges often inspire students to think about what's next. For some, this could mean connecting with people within the manufacturing or engineering industries or applying their skills in new ways. Here are a few ideas for how you can help students extend this challenge:

- Scaling objects works in both directions. Have students enlarge their Glowforge Catalog design using the skills that they developed in the Shrink-o-matic Challenge.
- Miniaturists are designers who specialize in making smaller versions of items. Have students recreate a room, an object, or another idea using their scaling skills. Explore the work of Chelsea Makes, Miniatur Wunderland Street View Trek, or Hamburg's Miniature World for inspiration.
- Help students become members of the thriving Glowforge Community. Submit students' scaled designs to the Glowforge Catalog or post them to the Glowforge Community's Free Laser Design board so that other creators can enjoy too.
- Scaling can be especially helpful when designing a workshop. Encourage students to use their scaling skills to help organize your workshop in the Condense the Nonsense Challenge.

Ready to take students to the next level? Try the Capstone Challenge Sustainable Strategies for Circular Design, where students apply their manufacturing skills to manufacture a sustainable product.