

Facilitation Guide: Capstone Challenge -Sustainable Strategies for Circular Design

Challenge

Students will apply circular design principles by redesigning a product. In doing so, they will gain a firsthand understanding of how circular design principles can create positive change and promote sustainability in manufacturing. Through this capstone challenge, students will create a detailed plan for implementing circular product design, which involves rethinking the manufacturer's operations, systems, or processes to promote sustainability. They will then share their findings based on their redesigns in a Circular Design Expo with their peers and community.

The ultimate goal of this challenge is for students to be able to communicate the advantages and impact of transitioning to a circular design approach for the manufacturer, the users, and the environment.

Rationale

Circular design is a critical concept in the modern manufacturing industry, as companies strive to reduce waste and promote sustainability. By offering hands-on experimentation and prototyping opportunities, this challenge provides a unique and engaging way to introduce students to these important principles.

The challenge involves redesigning a product to apply circular design principles and create a detailed plan for implementing them in a manufacturing context. Students will learn how companies can shift towards a more sustainable approach to product design.

In completing this challenge, students will develop practical skills in product design, prototyping, and problem-solving while also gaining a deeper understanding of sustainability in the manufacturing industry. Additionally, the Circular Design Expo will create the opportunity for students to practice communications skills like public speaking, create visual aids to convey a message, and learn adaptability and active listening skills in responding to audience questions.

Glowforge is a valuable tool for investigating the impact of circular design on manufacturing. Its precise cutting and engraving capabilities promote circular design principles, which reduce waste and produce long-lasting, repairable, and high-quality products. It can also work with existing materials and resources in innovative ways, promoting sustainability.



For students in manufacturing and design courses, Glowforge offers a streamlined design process that incorporates their existing skills into real-world experiences. Its quick and responsive prototyping capabilities allow for rapid exploration of circular design solutions, helping students iterate on their ideas and experiment with new approaches. This hands-on experience helps them develop practical skills and gain a deeper understanding of the importance of circular design in promoting sustainability.

For this capstone challenge, your students could innovate on a product from a previous design challenge or activity like:

- <u>Accessible Innovations Challenge</u>: Redesign a product using universal design to improve access for all users.
- <u>Level-up for Lefties Challenge</u>: Redesign products for safety and ease for left-handed users.
- <u>Think Inside the Box Challenge</u>: Redesign packaging to reduce waste and cost.
- <u>Reinventing the Ordinary: an Upcycling Challenge</u>: Extend the life of a material by upcycling it into a new product.

Or, depending on classroom constraints, have students identify and redesign a commercial product that would benefit from circular design principles.

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 2. Analyze and summarize how manufacturing businesses improve performance.

ISTE Standards for Students

- Innovative Designer 1.4.c Students develop, test and refine prototypes as part of a cyclical design process.
- Innovative Designer 1.4.d Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.
- Creative Communicator 1.6.b Students create original works or responsibly repurpose or remix digital resources into new creations.



Facilitation Steps to Support the Design Process



Explore

The Explore stage is where students focus on researching and investigating circular design. To ensure that students have the knowledge and skills they need to complete this stage, use the following steps:

- 1. Provide students with a brief introduction to the challenge, as well as relevant resources around circular design.
 - The <u>Ellen MacArthur Foundation</u> has a wealth of information on circular design, including videos and handouts. Explore their <u>YouTube</u> channel for specific industries or methods to curate videos you'd like your students to focus on.
 - The <u>World Economic Forum</u> has great resources on circular design, economy and manufacturing. You will need to make an account to access some of these resources. You may want to access the resources and then share them with your students.
 - This TEDx Talk, <u>How to design the circular economy</u> by Mart Drake Knight, discusses his team's journey building the first open access, circular economy for fashion. He explains sustainability and circular economy issues and how to build real solutions.
- 2. Provide students with question prompts from the Explore stage of the challenge to help inspire their research and consider how they can incorporate circular design principles into manufacturing. These articles address the impact on manufacturing:
 - <u>Circular Economy in Manufacturing</u>
 - Importance of the Circular Economy in Manufacturing
 - How can the Circular Economy Move Your Company Forward?
 - Importance of the Circular Economy for Manufacturing
- 3. Facilitate a class discussion that helps students consider the impact of circular design on manufacturing.
 - Make sure students understand and consider the manufacturing processes in circular design like supply chain, materials, energy consumption, and the end of life process.



At the end of this stage, it will be important for students to reflect on the research they did to learn more about circular design principles, and how manufacturing is affected. Encourage them to consider how manufacturers will have to change their processes in order to remain relevant. Help them focus on what aspect of circular design they might want to present on during the Expo.

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 potential products and consider how they could be redesigned to incorporate principles of circular design

Ideate

In this stage, students will take what they learned in the Explore stage and brainstorm and experiment with different ideas for redesigning a product using circular design principles. This stage allows students to explore as many ideas as possible without judgment. Remind students to consider how they can utilize Glowforge to redesign the product to reduce waste and increase recyclability or reusability. 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. Facilitate brainstorming activities to help students get thinking creatively. Try one of the following methods or use your own:
 - Allow students to brainstorm individually or in small groups to utilize multiple perspectives.
 - <u>SCAMPER</u>: SCAMPER stands for Substitute, Combine, Adapt, Modify, Put to Another Use, Eliminate, and Reverse. Students can use these prompts to generate ideas for how they can modify or adapt a product to make it less wasteful or extend its use life.
- 3. Champion and support divergent thinking. Ask open-ended questions, challenge assumptions, and suggest alternative perspectives. Use questions like:
 - What if you combined this product with another product?
 - What if you used a different material?
 - How are you challenging the traditional linear production model and approach to product design with the circular design principles?
 - How might you design this product to be more modular or adaptable so that it can be easily disassembled, repaired, or upgraded over time?
 - What alternative business models might be necessary to support a circular design approach, and how can you encourage companies to adopt these models?
 - What role do consumers play in promoting circular design, and how can you encourage them to make more sustainable choices with your design?

At the end of this stage, students will have generated multiple ideas for product redesign and be able to narrow their focus in order to develop a design that incorporates circular design



principles. Their idea should help them present their finding on circular design and necessary changes to manufacturing for their Expo presentation.

Before moving on, students should consider which ideas and which parts or components they will need to design using Glowforge. Once they are finished, students will continue to the Design stage, where they will select one or two ideas that they will develop further.

Design

In this stage, students will develop their ideas from the Ideate stage to draft a detailed plan for their circular designed product. Students should focus on one or two ideas to better understand their needs and final design before printing. Encourage students to consider the effect their design might have on the manufacturing process. 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 Design stage of the challenge to help them design their product.
- 2. Ask students to compare their redesign to the original version of the product. Have them explain how their design meets the circular design principles. Use prompts like:
 - What features or elements of your design keep it in use for as long as possible?
 - How can it be repurposed or recycled when it's no longer needed?
 - What impact does your design have on sustainability?
- 3. Introduce, review, or model available design software options, including <u>the Glowforge</u> <u>App</u>.
 - Assist students as they create sketches or digital mockup of their redesigned product.
 - Remind students that Glowforge can engrave from JPG or PNG image files and cut or engrave from SVG and PDF files. Students can create a design in software that they already use, convert it to one of the supported file types, and print using Glowforge.
 - Review page 28 in the <u>Glowforge Educator Guide</u> for more software tools and information.
- 4. Ensure that students have a clear understanding of the designs, materials, and tools needed to create a working prototype.
 - What materials and tools will you need to create a prototype of your design?
 - What challenges or limitations might arise during the prototype stage?
- 5. Help students decide on a format for their presentations for the Circular Design Expo. Encourage them to be creative with the format. Remind them to incorporate their product redesign and other visuals to enhance the main points of their presentation.

At the end of this stage, students will have a detailed plan for their product, including sketches or digital mockups, as well as designs for any assets they may need for their presentation. They should be able to explain how their redesign keeps the materials in use from how it's made, to how it can be repurposed or recycled at the end of life. They should develop a plan about which



manufacturing processes will have to change or be adapted to accommodate the product's redesign and ensure its successful production.

Simultaneously during of the design stage, students will be developing their presentations for the Circular Design Expo. At this point they will have a product, research and their reasoning for the redesign. Provide them guidance as they develop their presentations. Share resources and helpful suggestions like options for different presentation formats, and encourage students to use storytelling to highlight their redesign and findings.

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 a physical print. Students will select one of their fully developed design plans, print necessary elements on the Glowforge, and test their techniques. They will then create and rehearse their presentation on circular design and its effects on the future of manufacturing. To ensure that students have the knowledge and skills they need to complete this stage, use the following steps.

- 1. Model how to use Glowforge in a safe and efficient manner.
 - Review the <u>Glowforge safety guidelines</u>.
 - Remind students of any applicable classroom or school policies.
 - Use this <u>video</u> to demonstrate how to use Glowforge.
- 2. Prompt students with questions to help them develop their prototypes. These might include:
 - What are the pros and cons of using different materials and techniques? What materials will you use to achieve the principles of circularity?
 - Are there other materials that might work better or offer opportunities for more sustainability or customization?
- 3. Encourage students not to be afraid to make changes and adjustments as they go and use each prototype iteration as an opportunity to learn and improve their design.
- 4. Give students the time and resources needed to print Glowforge elements for their redesigned product, assemble, and test their finished prototype.
 - Create a classroom print schedule to ensure that all students are able to produce the elements they need efficiently.
 - Provide students with <u>earth-friendly art supplies</u> to add additional aesthetic elements to their redesigned product.

At the end of this stage, students will have a finished prototype that demonstrates their redesigned product for evaluation. They should have a good understanding of how the production of their redesigned product will affect the manufacturing processes and explain what aspects of the process may need to change.



Additionally, students will have finished preparing and rehearsing their presentation for the Expo. They should have their format finalized, visual aids, artifacts and presentation materials ready. Students may need to rehearse their presentation format with their materials several times before sharing out to a wider audience.

Before moving on, students should review their finished print to ensure it aligns with their vision and functions as intended. Students may need to test multiple times or return to earlier stages of the design process before moving on. Once they are finished, students will continue to the Evaluate stage where they will receive feedback on their finished product and presentation.

Evaluate

In this stage, students will evaluate their redesigned products 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 with their original intent. 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 to help them reflect on their product.
- 2. Encourage students to share and discuss their ideas to generate feedback and suggestions from their peers to refine and enhance their 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, affinity mapping, or a concentric circle discussion, 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:
 - Are there any areas for improvement or additional features that could be added to enhance the circular design of your product?
 - If making additional changes to your product redesign, which of the design process stages will you return to?

At the end of this stage, students have reflected on the strengths and areas for improvement of their circular redesigned product. Through this experience they will have gained a deeper understanding of sustainability in the manufacturing industry.

Students will showcase their understanding of circular design in manufacturing by presenting their findings on the strengths and areas for improvement at the Circular Design Expo. You may want to use the Assessment Suggestions to assess student work or provide the Extension Activities to challenge them further.



Supplemental Supports

- Help students understand industry-recognized certifications like <u>Cradle to Cradle</u> <u>Certified®</u> or <u>B Corp Certification Best for the World 2022 Lists</u> products.
- Encourage students to delve deeper into the UN's Global Goals or Sustainable Development Goals check out their resource <u>Goal 12: Responsible Consumption and</u> <u>Production</u> and learn how to use and produce in sustainable ways that will reverse the harm that has been inflicted on the planet.
- If students are interested in learning more about planned obsolescence or the Right to Repair movement, encourage them to explore these resources from the <u>Sierra Club</u> and <u>Wirecutter</u>.
- The <u>Circular Design Guide</u> from the Ellen MacArthur Foundation and IDEO has lots of great resources to help students consider Circular Innovation and dive deeper into making sustainable items or redesigning current items to be more sustainable.

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 researching and designing for circularity in the manufacturing process. Ask students to write or record a video about what they learned throughout the challenge and how their learning will impact their future designs. 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:

- Sustainability: Were the materials used in the product environmentally sustainable? Were they able to be reused, recycled, or repurposed at the end of the product's life?
- Flexibility: Were any trade-offs necessary to incorporate the circular design principles, and if so, were they acceptable?
- Feasibility: In what ways did the circular design principles affect the cost of production? Were there any cost savings as a result of the circular design principles, and if so, how significant were they?
- Manufacturing: How were manufacturers impacted by the circular design principles, and in what ways?



- Communication: Were the circular design principles easy to communicate to your audience and did they resonate with them?
- Creativity & Innovation: Did you come up with an innovative solution that demonstrates creativity, originality, and resourcefulness? Were you able to successfully convey thay message through your presentation?

Educator or Peer Assessment

Educator or peer assessments allow educators or students to review the quality and effectiveness of the finished product. The assessment can be based on specific criteria, such as process and form of the circular designed product, or use a more open approach like a showcase. Some criteria to consider may include:

- Sustainability: Does the redesigned product eliminate waste, circulate or reuse materials at their highest value, and address regenerating nature?
- Manufacturing: What is the economic and environmental impact of implementing the proposed circular redesigned product? How will it affect the manufacturing process?
- Quality and design: Is the finalized prototype design well-made, durable, and constructed with quality materials?

Extension Activities

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

- Host a Circular Economy Showcase for students to present their findings and solutions to local or state government agencies responsible for environmental policy, sustainability, or economic development.
- Challenge students to review and apply additional industry standards like <u>Cradle to</u> <u>Cradle Certified®</u> or <u>B Corp Certification</u> to their designs. How will this change their design and manufacturing processes?
- Invite local manufacturers, businesses, or the local chamber of commerce to partner with students and provide feedback on their designs. Have an Economic Symposium for students to present their recommendations to this audience. Ask the companies to provide an item they manufacture so students can suggest a redesign to their manufacturing process to reduce waste, increase efficiency, and move towards a more circular economy.
- Work with a local organization to employ circular design principles to create an initiative that addresses a specific sustainability challenge in the community. Challenge students to design a system that eliminates waste and pollution, circulates products and materials at their highest value, and regenerates nature. They can create a practical solution that can be implemented in the community that has the potential to make a significant positive impact on the environment.