DESIGN & PITCH CHALLENGE

Transformative Structures

Welcome to the Design & Pitch Challenges in STEM!

Whether this is your first time implementing a Design & Pitch Challenge or your ninth, we are excited to have you on our team of innovative practitioners who are bringing entrepreneurship and career readiness to the forefront of STEM. In this document, you will find a variety of resources that will help you implement the Design & Pitch challenges with your students. These resources include:

1. an overview of the Design & Pitch (D&P) Process with all Challenge Links;
2. a breakdown of each phase of the process in the context of the Transformative Structures challenge;
3. teacher tips from the D&P team and other teachers who have implemented the challenges in their classrooms.

This guide is specifically designed around Transformative Structures, which is one the nine D&P challenges aligned to high school mathematics standards. In the Transformative Structures Challenge, students will need to design a physical structure that can be transformed to support multiple purposes. While completing this challenge, students will need to describe how their structures can be transformed to support multiple purposes; provide detailed descriptions of those transformations; and build a 2-D model (or 3-D if they want!) of their structure including its transformations.

Learn About the Model

If you are using Design & Pitch (D&P) Challenges for the first time, you will want to familiarize yourself with the D&P model and some things to expect when running any challenge. To do that, go check out our Model Overview document. It will tell you all about general implementation strategies, potential pacing, and things you will need to prepare before launching a challenge.

After you feel familiar with the D&P model in general, come back to this document to learn all about the Transformative Structures challenge. In this guide, you will find information about each phase of the challenge (Launch, Research, Prototype, Justify, and Pitch). Additionally, you will find tips for things to look out for or try to draw out of your students as they engage with the challenge.

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Transformative Structures: Complete Links

This table includes all links contained in the Transformative Structures challenge. It is intended to be a handy reference that you can use to quickly find what you need. The links will be explained in detail throughout the remainder of this teacher guide.

NCSU Website - Transformative Structures Challenge

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Transformative Structures

Challenge Overview

In the Transformative Structures Challenge, students use geometric transformations to design physical structures that support multiple purposes. Use this guide to learn tips and strategies for implementing the Transformative Structures challenge with your students. We hope you have fun inventing transformable products and structures!

Target Grade Level:	**Discipline or Course (Audience):**	**Math Topics:**
Grade 10	Math 2, Math 3, or Geometry	Translating, rotating, reflecting, and dilating figures in the plane.
Key Vocabulary: Translations, rotations, reflections, dilations		

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LAUNCH

Once you have selected and prepared for a challenge, it is time to Launch the challenge with your students. Each challenge includes a Challenge Statement video, in which the Challenge Champion (each challenge has a unique Champion to guide the students through the challenge) establishes the context or problem and formally issues the challenge. In Transformative Structures, Dr. Andre Mazzoleni from North Carolina State University discusses how his team builds transformable rovers to explore a variety of terrains and introduces the components of the challenge.

Challenge Statement

Scenario

Following the Challenge Statement video is a Scenario section, where the challenge is briefly summarized for the students. This section also begins to explore the significance of the issue so as to convince students that this problem deserves their attention. In the In Transformative Structures, for example, the scenario presents multifunctional products and spaces as a potential solution to a range of community issues including lack of accessibility. Starting with the relatively familiar examples of multifunctional tools or a wheelchair-accessible van, the purpose of this section is to get students interested in finding their own solution to the problem.

As you launch the challenge with your students, you might consider showing them additional videos that emphasize the issues in this challenge. For example, you might show a video featuring innovative multi-functional products, or designers discussing the challenges people experience when spaces are not accessible. The goal here is to tailor this section of the challenge to your students' interests and grab their attention; this is the time to bring out your teacher 'hook!'

Challenge

The final piece of the statement of the specific design challenge students need to address. This section outlines the challenge and describes the criteria for a successful solution. While the students are encouraged to be innovative in their solutions, there are requirements that they will need to meet. Primarily, these requirements ensure students are engaging with the targeted math concepts. For Transformative Structures, these concepts are largely related to understanding geometric transformations in preparation for using those transformations to prove theorems relating to congruence and similarity.

During this challenge, students will explore how to use rigid and non-rigid transformations to map preimages onto images.

Brainstorming

As you introduce the challenge to your students, it is important to allow them to brainstorm along the way. They might be thinking about issues they find important or possible solutions, business strategies or about the final pitch, and questions they have or things they will need to know along the way. As such, they might need help organizing their thoughts, and brainstorming as a class or small group can help them do this. One strategy is to ask them to discuss things they noticed in the video and challenge statement. Another strategy is to have them discuss things they still wonder about. If students have already been organized into groups, you can have them record their brainstorming somewhere that will be accessible for all group members; if you are brainstorming as a class, you might consider recording ideas on a poster board or bulletin board so the class can refer back to their original thoughts later. These thoughts can include words, pictures, or anything else the students come up with during their brainstorming session.

Group Norms and Expectations

After teams have been formed, it is also important for members to discuss norms and expectations for their team in order to develop accountability. This can be done during the brainstorming session or after, but it is important to have teams set their expectations early in the process so that they can be referred back to as the challenge progresses.

Teacher Tips

The scenario is a good place to get students thinking about their communities. Consider centering this discussion around transformable and multi-functional structures that students have seen or heard about in their communities. These could include a variety of structures, such as wheelchair accessible school buses or school gyms that transform depending on the sport. Consider asking students how these structures transform and what problem they solve in doing so.

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As students read through the challenge statement, you may want to have a conversation about what counts as a physical structure and what it means for the structure to transform to support multiple purposes. How you conceptualize these terms is up to you and your students. However, to elicit the intended mathematics of geometric transformations, these structures must be transformable through folding, sliding, rotating, or dilating parts of the structure.

While students make sense of the challenge statement, it could also benefit them to discuss the math terms in the second and third bullets. Specifically, students should be aware that their structures must be transformable by incorporating translations, rotations, reflections, or dilations of parts of the structure. Thus, it will be important for students to refresh their memory of what each of those terms means.

The Process: Designing Solutions

The Designing Solutions document provides a structure for students to follow as they progress through the Design & Pitch Challenges. Each challenge follows the same structure, so once students are familiar with this document, they will be able to navigate all of the Design & Pitch Challenges. While this is not an activity in and of itself, you might choose to have students begin by exploring this outline. What do they notice? What do they wonder? This exploration, should you choose to do it, can be done on their own, in small groups/teams, or as a whole class. There is also a PDF version of this document in case you or your students do not have access to the internet during work time.

Think About It

Description:	**Time Frame:**	**Suggested Grouping:**
Formative questions to facilitate student understanding and reflection of the current phase of the challenge.	5-10 minutes	Individual or Small Group

Each phase of the competition includes a set of “Think About It” questions that are intended to help students understand and reflect on this phase of the challenge and

move on to the next phase. ***Specifically, these questions ask students to think about preliminary ideas they might have for a solution as well as information they might need to develop a solution that meets the needs of their consumers.*** As such, we intend for these to be informal questions that students use to reflect on their thoughts. You can pose these questions in a variety of ways. For example, you might choose to display them on a whiteboard at the front of the classroom or on a slidedeck and have students discuss in their groups. You might choose to formalize this discussion by adding the questions to your learning management system and having students record their responses via discussion boards or other submissions.

For the Launch of Transformative Structures, there are two Think About It questions:

1. What ideas do you have for your solution?
2. What information do you need to create a viable solution for your target consumers?

Additional reflection questions are included to help jumpstart student thinking. For the Launch of Transformative Structures, these include:

- What structures that transform have you seen in the past? What purpose did they serve?
- Think about a problem in your community. What type of structure that transforms would help address this issue?

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RESEARCH

In this section, students start to Research and brainstorm possible solutions to the problem. They are encouraged to be creative and daring, rather than aiming for perfection. There are some helpful resources available to them to get them started, but generally students know how to start looking for the information they need to make their ideas possible. Thus, as much as possible, step aside and just let them work! It is perfectly fine if they do not look at any of the links in the helpful resources, but if you notice any groups getting stuck or unsure how to begin, that can be a great place to get them curious and inspired.

Helpful Resources

Description:	**Time Frame:**	**Suggested Grouping:**
Students are introduced to some of the resources and tools they can use to help them develop their solution.	Introducing the Resource: 5 - 10 minutes Using the Resource: Varying time frames throughout the challenge as students re-engage with the Helpful Resources.	Individual or Small Group

In this part of the challenge, students will conduct the research necessary to design and market their solution. We have included several resources on the Design & Pitch website that students might find helpful as they learn more about the challenge and context. These resources include articles, websites, videos, and more. Students are encouraged to explore these resources and go beyond those listed on the website to learn as much as they can about designing transformable and multi-functional structures. You might have to do some research with the students and suggest phrases for them to Google if they are trying to find additional resources to help develop their ideas and businesses.

Math Resources

This section also includes links to math resources designed to help students learn the mathematics needed to build solutions to the challenge. Transformative Structures includes math resources that are intended to help students understand and develop the mathematical skills necessary for this challenge. Specifically, these resources present a situation related to the context of the challenge and asks students to think about the math that is happening in the situation, as well as how they might apply the math to their developing solutions. As such, this resource should be presented to students after they have begun designing their solutions and are reaching a point where they need to know more mathematical skills in order to continue designing. Although the math resources are included in the Research phase of the competition, they are most useful in the Prototype phase. Thus, detailed description of the math resources, including tips for using them with students, can be found in the Prototype section of this guide.

Business Models

Description:	**Time Frame:**	**Suggested Grouping:**
Students learn about different types of business models.	Introducing the Resource: 5 - 10 minutes	Small Groups or Whole Class
Key Vocabulary: Manufacturer, aggregator, retailer, freemium, subscription, nonprofit, consulting		

One of the first questions students must answer about their business is how their solution will reach their target customers. Identifying a business model is key to answering this question. Consider introducing the need for a business model by having students brainstorm as many types of businesses as they can think of and describing how those businesses make money. Then, during the discussion, help students recognize that each business they mentioned has a way of making money on their idea and getting their product or service to the consumers who need it. Students will need to draw on this line of thinking to define how their business will similarly make money and reach their target consumers.

For students who are having difficulty describing how their business will make money, consider giving them the following list of common business models. This list is not comprehensive; students are welcome to research and select a business model that is not on this list. To support students to make sense of the document, consider asking them to identify businesses that fit each category (other than the ones mentioned).

One note about the nonprofit model: Many students think of nonprofit organizations as not needing to make money, but this is not true. If you have students who choose this model, you might ask them questions about why a nonprofit needs to make money and what it truly means to be a nonprofit organization.

Business Model Types Document

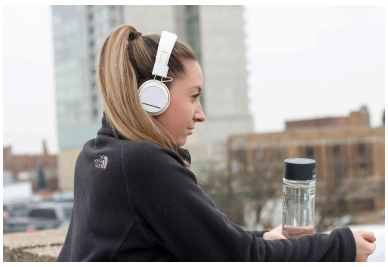
There are many ways to run a business. As you think about how to make your business sustainable, consider these different business model options. Even if you've never heard of the names, you're probably familiar with many of these models. Not every model will work for every idea. Think hard, build on ideas, and be creative!

Manufacturer: The company builds a product and sells it to customers. Revenue (money earned) comes from the customer. Expenses include materials, labor (e.g. building the product and making sales), and advertising. The companies that build your iPod, your favorite skateboard, and your family car use the manufacturer model.

Aggregator: The company organizes a service offered by many different people and companies under one brand. For example, Uber uses the aggregator model because it organizes taxi services under the Uber name. Revenue comes from a percentage of the ride cost. The drivers must sign a contract agreeing to follow Uber's terms.

Retailer: The company buys products from a distributor and sells them to the consumer. Expenses include the cost to buy the products, advertising, managing the online or physical marketplace, and labor. Revenue comes from the customers. When you buy a new video game from a gaming store, you are using the retail model.

Freemium: The company offers a basic service for free, but charges extra for additional features. For example, you might stream music for free, but you have to listen to advertisements. Music without ads is considered “premium” and costs extra. Revenue comes from advertisers and from premium users. Expenses include the cost of maintaining the service platform, labor, and paying manufacturers for the product.



Subscription: The company gets customers to pay a regular fee for access to their service or product. For example, Netflix uses a subscription model. Revenue comes from subscribers. Expenses include maintaining the service platform (e.g., websites, servers, etc.) or the cost to produce or purchase the product included in the subscription (e.g., movies), advertising, and labor.

Nonprofit Organization: The nonprofit organization is a business that is operated for a collective, public, or social benefit. Examples of nonprofit organizations include: American Red Cross, American Cancer Society, and Habitat for Humanity. Expenses include advertising, fundraising events, facilities, and labor. Potential revenue sources include profit from products and/or services, donations, corporate sponsorships, and government grants. Any revenue generated that exceeds expenses (i.e., profit) is reinvested in the organization and used to extend the organization’s mission.

Consulting: The company (could be an individual or a group of individuals) provides services and guidance to another business in a specific area of expertise. Examples of some of the types of services consultants provide to their clients include gathering and sharing information, recommending solutions to targeted problems, supporting implementation of recommended solutions, and facilitating decision making processes. Expenses include advertising, potential office space, labor, and travel expenses. Revenue comes from the consulting fees paid by the business that hired the consultant.

Think About It

Think About It questions serve the same purpose in all phases of the challenge. See the Launch Think About It questions for a description of how to use the questions. The Research phase of the challenge includes the following Think About It questions:

1. After reading through the helpful resources, what ideas do you have for your solution?
2. What problem will you solve with your business solution?

Additional reflection questions are included to help jumpstart student thinking. For the Research phase of Transformative Structures, these include:

- Which resource(s) did you find the most helpful or beneficial to you and your team? Why?
- Which resource(s) sparked the most ideas for you? Why?
- Were you surprised by anything you read? If so, what? How can you use this new information to help build your solution?
- What problem did you want to solve after reading and watching the Launch materials? Do you still want to solve the same problem? If so, how did the resources help you solidify that decision? If not, what made you change your mind?
- Why did you decide to solve the problem you chose?

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PROTOTYPE

During the Prototype phase of the design process, students build, test, and refine prototypes of their solutions. The prototype for this challenge should be a 2-D model with detailed instructions showing how the structure can be transformed using translations, rotations, reflections, or dilations. Students can build their prototypes using programs like GeoGebra or Desmos Geometry. Students may want to build 3-D models of their structures. If so, encourage them to use the 3-D graphing feature of GeoGebra or a 3-D design program like TinkerCAD. Although students are not required to build 3-D models of their structures, doing so may support students' spatial reasoning especially as it relates to visualizing geometric transformations. Students are encouraged to test their designs and get feedback, then make it better based on what they learn. This could happen through more research, conversations with the teacher and external experts, or tinkering with the prototype.

Tech Tools

Description:	**Time Frame:**	**Suggested Grouping:**
Students are introduced to technology that they can use to help them develop their solutions.	Introducing the Resource: 10 - 15 minutes Using the Resource: Students will refer back to this document as they develop their solution.	Individual or Small Group

Each of the D&P Challenges includes Tech Tools that are designed to help students prototype their solutions and develop a deeper understanding of the mathematical content embedded in the Challenge. For Transformative Structures, if you choose to have your students use them, the Tech Tools are GeoGebra and Desmos Geometry. These are free online websites that allow students to create and transform models of their physical structures.

Math Resources

Description:	Time Frame:	Suggested Grouping:
Activity designed to support students in learning the mathematics concepts and skills needed to build their solutions.	Introducing the Resource: 30 - 45 minutes Using the Resource: Varying time frames throughout the challenge as students revisit the Challenge Statement.	Small Groups or Whole Class
Key Vocabulary: Rigid transformations, non-rigid transformations, translations, reflections, rotations, dilations		

The tools in this section can be used to help students understand targeted math concepts that they will need to develop their solutions. Some of these resources are static documents that serve as explanations or walkthroughs, while others are dynamic and might include websites or other digital tools that students can use to explore the concepts on their own or with their team members. You might also find that students need additional instruction. One way to help students achieve the intended math goals for a challenge is to have small group workshops with your students. These workshops allow you to instruct and remediate targeted math concepts as needed. You can run workshops with select students, a single team, multiple teams, or the whole class depending on the needs of your students. You can present this resource in a variety of ways. For example, you might choose to provide a handout and have students work through the questions in their groups. You might choose to host a workshop, where groups can send representatives to attend, and you work through the resource with that small group. You might choose to formalize this work by adding the questions to a Desmos activity or your learning management system and having students record and submit their responses.

In the Transformative Structures math resource, students will explore how to describe transformations that map one figure (a preimage) onto another (image). The resource starts with a brief review of the four rigid and non-rigid transformations that are discussed most often in high school math courses: translations (rigid), rotations (rigid),

reflections (rigid), and dilations (non-rigid). A link is provided to a GeoGebra applet that allows students to explore these four transformations. As students explore these applets, encourage them to pay close attention to the relationship between the original figures and the new figures. In particular, students should look for points/lines of rotations or reflections, centers of dilations, angles and directions of rotations, and magnitudes and directions of translations. Students will need this information to build their solutions.

After reviewing the four transformations, students have the opportunity to explore how to describe transformations that map a given figure (preimage) onto a new figure (image). In addition to addressing math standards relating to understanding transformations, this work will also prepare students for using transformations to prove geometric theorems relating to congruence and similarity. The math resource includes three examples of transformations. Example 1 involves a rotation. Example 2 involves a translation, reflection, and then a dilation, though other sequences are possible. Example 3 involves a dilation. Each example includes a static image of the preimage and image and a dynamic GeoGebra applet with the same figures. Students can use either the static image or dynamic applets to describe the transformations, but encourage students to use the dynamic applets to test whether the transformations correctly map the preimages onto the images.

Teacher Tips and Answer Key

A geometric transformation is a function that generates a new figure (called an **image**) by changing the points in a given figure (**preimage**). That is, the points that make up the preimage are inputs of the function and the points that make up the image are outputs.

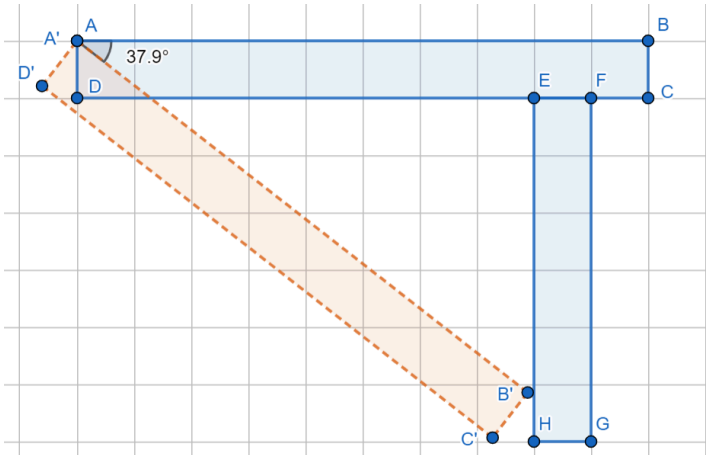
Use the following interactive applets to review common examples of [v]rigid[/v] and [v]non-rigid[/v] transformations.

- **Translations, Rotations, Reflections, and Dilations** - ***Note:*** This applet refers to a dilation as an “enlargement.”

Using Geometric Transformations to Describe the Features of your Prototype
Using the language of geometric transformations can help you effectively explain how your product works and describe the different forms it can take.

To describe a transformation, you need to include: (1) *the* ***type of transformation***, (2) the ***point or line of reference***, and (3) a description of ***how the figure is being transformed***. If you need to use more than one transformation, provide this information for each transformation in the order it was performed.

Example 1: This image shows a transformation that maps rectangle ABCD onto rectangle A'B'C'D'.



1. Describe the transformation. Use GeoGebra link to check your answer. ***Note:*** The apostrophe (') symbol is used to indicate that a point is an image of another point with the same name. For example A' is the image of A.

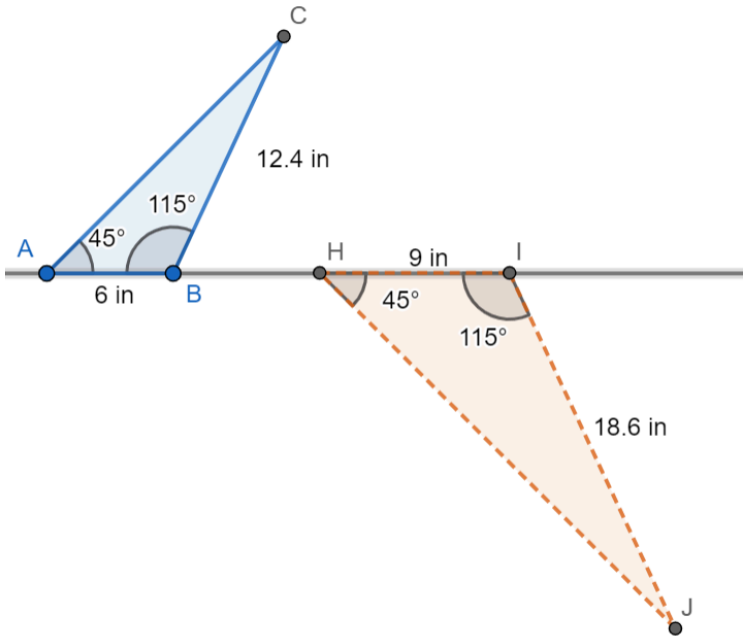
[t] Rotate rectangle ABCD 37.9 degrees clockwise about point A. Consider asking students how they determined that the angle of rotation should be 37.9 degrees. Consider asking students how they know that this will result in rectangle ABCD coinciding with rectangle A'B'C'D'. [/t]

2. How could this transformation be used in an actual physical product? Use your imagination.

Example 2: This image shows a blue figure that can be mapped onto the orange figure using a sequence of transformations.

1. Describe the sequence of transformations that map △ABC onto △HIJ. Use GeoGebra link to check your answer. ***Note:*** In this example, you will need to identify the pairs of corresponding points.

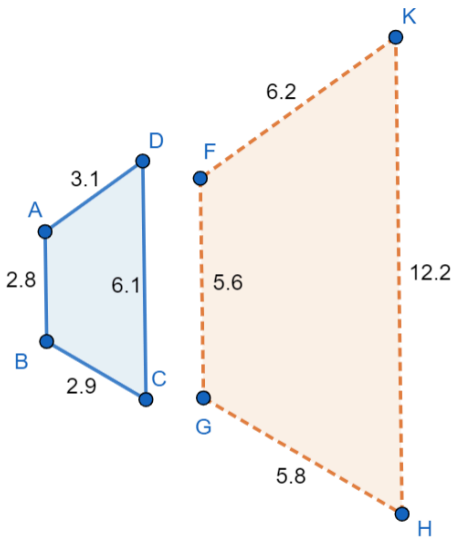
   [t] Encourage students to describe the transformations in terms of mapping points and line segments onto corresponding points and line segments. This will prepare students to use transformations to prove geometric theorems. For example, one sequence of transformations that will map △ABC onto △HIJ is to translate △ABC so that point A coincides with point H. Reflect △ABC across the line AB. Dilate △ABC by a scale factor of 1.5 with a center of dilation located at point A. Other sequences are possible. [/t]



2. How could this transformation be used in an actual physical product? Use your imagination.

Example 3: In the following image, the blue quadrilateral can be mapped onto the orange quadrilateral using a dilation.

1. Use GeoGebra link to find the center of dilation and scale factor that maps quadrilateral ABCD onto FGHK.



Scale Factor: [t] 2 [/t]

Center of Dilation:

Note: to identify the center of dilation, describe how to find the point using the given figures. [t] Students may use guess and check to experiment with possible locations. One way to systematically find the center of dilation is to draw lines through pairs of corresponding points (e.g., A and F). These lines will all intersect at the center of dilation. [/t]

2. How could this transformation be used in an actual physical product? Use your imagination.

Your Turn

Use GeoGebra or Desmos to sketch your structure. Be sure to include at least two forms of your structure and a description of the transformations needed to use one form of the structure to create the other.

Think About It

Description:	Time Frame:	Suggested Grouping:
Formative questions to facilitate student understanding and reflection of the current phase of the challenge.	5-10 minutes	Individual or Small Group

Think About It questions serve the same purpose in all phases of the challenge. See the Launch Think About It questions for a description of how to use the questions. In the Prototype Think About It questions, **students are asked to think about the prototyping process, specifically how it helped them develop their idea and how the prototype they developed creates value for their consumers.** These questions include:

1. What did you learn about your idea by prototyping it?
2. How does your prototype create value for your consumers?

Additional reflection questions are included to help jumpstart student thinking. For the Prototype phase of Transformative Structures, these include:

- After you designed your first prototype, did you have to make any changes before you reached your final solution? If so, what were the changes, and why did you make them? If not, how did you know you had the perfect solution?
- How did the process of changing your design influence the way you thought about your solution?
- Why would consumers want your solution?
- How did your consumers influence each redesign of your solution?

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JUSTIFY

Throughout the process of developing their solutions, students are asked to Justify their ideas. Through completing the Key Business Proposition, they justify their solutions by showing that it can be the foundation of a viable business. Through working on the Technical Brief, they demonstrate all the thought and research that went into their design. You may also consider having them keep a journal or record of their thought processes and the decisions that they have made along the way. During this phase and approximately halfway through the competition, students should participate in an Expert Check-In to practice explaining their ideas and to receive feedback from a new perspective.

Key Business Proposition

Description:	**Time Frame:**	**Suggested Grouping:**
Students reflect on their solution and enhance its design to meet customer needs.	Introducing the Resource: 10 - 20 minutes Using the Resource: Varying time frames throughout the challenge as students re-engage with Key Business Proposition.	Small Groups or Whole Class
Key Vocabulary: Creating value, customers, consumers, elevator pitch		

Developing a Business

The Design & Pitch Challenges are a great way to get students to think creatively about solving real-world issues, but they are also about building a viable business so that they can make their solutions actionable. As such, one part of the D&P Challenges that students must consider is the Key Business Proposition, which supports students as they define how their solutions create value for customers or consumers.

Key Business Proposition

Once students have decided on the model for their business, they can begin working on the Key Business Proposition. This document is designed to get students thinking about a variety of business-related questions, including the following:

- Who are your customers and/or consumers? What do they want out of a solution?
- Why do they need your design more than someone else's?
- How does your solution enhance what customers/consumers like about their situation and fix what they dislike?

We find that students often lose sight of the customer/consumer through the process of designing their solution, and the Key Business Proposition can be used to remind them of the ultimate goal: design a solution to *help* someone or some community. This is another opportunity to drive the students back to the targeted math goals. Asking questions like "How will you precisely describe the features of your solution to your customers? How will you convince your customers that your physical structure will meet their unique needs?" and "What aspects of your product will make customers want to buy it?" is a great way for students to think about both the math and the needs of their customers/consumers. You might also encourage students to think about their own experiences with similar products as they begin to justify what customers/consumers want or need.

Teacher Tips

The Key Business Proposition includes a script for developing an elevator pitch. The elevator pitch script is meant to get students thinking about the important pieces of a pitch and to practice explaining their ideas clearly and concisely. It is not meant to be a script for the final pitch. Students will need to add a lot of information for the final pitch. It can sometimes seem that the Key Business Proposition comes too early for students to be ready to write an elevator pitch, but it usually is very helpful to get students thinking about the decisions that they will need to make for their final pitch and to practice explaining and defending their ideas.

Technical Brief

Description:	**Time Frame:**	**Suggested Grouping:**
Students reflect on their process and describe the specifics of their solutions.	Introducing the Resource: 20-30 minutes Using the Resource: Varying time frames throughout the challenge as students re-engage with Technical Brief.	Small Groups or Whole Class
Key Vocabulary: Translations, rotations, reflections, and dilations		

The Technical Brief, or “Tech Brief,” gives students the opportunity to reflect on the D&P process and their solutions and connects directly to the targeted math concepts. It is also a chance for the students to explain their solution in greater detail for the investors. As such, it can be completed along the way or after the final pitch and provides you the opportunity for small group instruction as needed. Some of the questions ask students to identify strengths they noticed and challenges they overcame along the way, so you might want to encourage students to be thinking about these items as they are working on their solution.

There are two primary parts to the Tech Brief. Part 1 is common to all of the Design & Pitch Challenges and asks students to reflect on the process of developing their solution. Part 2 is unique to each challenge and focuses on the targeted mathematical concepts of the challenge. In Transformative Structures, Part 2 of the Tech Brief asks students to describe how their structure will address a community need as well as how it utilizes transformations to serve multiple purposes. Students are asked to provide a 2-D model of the structure and describe the specific characteristics of the transformations that are needed.

Teacher Tips

Depending on when you decide to introduce the Tech Brief, you might consider starting this introduction by asking students to think about their pitches. Are they going to be able to include all of the information about their product in the pitch? No. Are they going to describe the process of developing their product in the pitch? Not entirely. Once students come to this realization, you can introduce the Tech Brief.

Students are often unaware of the many ways in which their solutions evolved over the course of the competition. Encourage them to think about what their initial design looked like during the brainstorming phase and what their final product looks like now. What is different? Likely something! Why did they make the changes that they did? .

Part 2 of the Tech Brief provides an opportunity to assess your students' mathematical understanding and help them formalize their mathematical reasoning. As such, you can adjust the components of this part to meet the needs of your students. Just remember that this section is aligned with the Tech Brief Grading Rubric, so any changes you make to this component will need to be made in the Rubric, as well.

Tech Brief Rubric

Description:	**Time Frame:**	**Suggested Grouping:**
Students review the Technical Brief Grading Rubric and develop an understanding of the expectations for the Technical Brief.	Introducing the Resource: 10 - 20 minutes Using the Resource: Varying time frames throughout the challenge as students re-engage with the rubric as they develop their Technical Brief.	Small Groups

The Technical Brief Grading Rubric was designed to help teachers assess the mathematical content underlying students' solutions. The rubric includes key components of a complete solution but stops short of making recommendations for how grades should be assigned. The rubric might also be helpful for students. Consider encouraging students to review the rubric before and while they complete the tech brief so that they know the expectations for a high quality solution. In keeping with the entrepreneurial spirit, criteria are rated as "Excellent," "Good," "Improving," or "Getting Started" in order to encourage students to keep working hard. You might find it is worth your time to have a discussion with students about how they can use this rubric to help them develop their Tech Brief, their product, and their pitch.

Expert Check-Ins

Expert Check-Ins should take place approximately halfway through a pitch competition and should be conducted by people external to the class who have not heard anything about students' solutions. There are several purposes for the expert check-ins. First, they give students additional practice explaining and defending their solutions to people who have not been hearing their solutions throughout the competition. Second, they give students an opportunity to receive feedback on their designs from people other than their teacher, which can motivate them to make revisions and improve upon their solutions. Finally, they provide a mid-challenge benchmark that can motivate a needed sense of urgency with the final pitch looming. Thus, students do not need to be done or close to done with their prototypes, KBPs, or pitches to participate in an Expert Check-In. Regardless of the progress they have made, students often rise to the occasion during Expert Check-Ins and are to defend their ideas and benefit from the feedback they receive.

Experts should be recruited from outside the classroom. They can include anyone who can comment on students' solutions from an entrepreneurial or consumer perspective. This can include people who are experts in a field related to the challenge context, have experience with the products students are designing, or are members of the school community (e.g., other teachers, administrators, or parents). Below are tips that can be given to experts to help them engage with students effectively. Experts should use these tips as needed. They do not need to ask every question or respond to every bullet point.

Tips for External Judges during the Practice Pitch and Expert Check-Ins

The goal of the practice pitch and the expert check-in is to give students an opportunity to practice explaining and defending their entrepreneurial solutions. When listening to groups, imagine you are an investor deciding whether to invest your money in the group's company. As much as possible, assume a position of curiosity and treat students as knowledgeable about their product and business.

This is also an opportunity for you to share your expertise. We encourage judges to draw on their experiences to give feedback and make suggestions for ways students can improve their products/services and businesses.

Things to consider while listening to students:

1. Did the group convince you that their product or service solves a real and important problem?
2. Did the group convince you that their business will work?
3. Do the students appear to be invested in their business?
4. Are you convinced there will be customers? If not, what would convince you?
5. Does the team have a plan for how their company will make money?

Sentence starters for feedback and probing questions: the following sentence starters can be used to frame your feedback. Be sure to tailor these sentence frames to fit the product you are reviewing.

1. I really like that your product is timely and solves an important problem. Can you tell me more about how your product/service works?
2. Who are your target customers or users? Why would they want to use your product/service?
3. How did you decide on your business model? Have you thought about…
4. I like that you included a prototype of your solution. Can you tell me more about what it would take to build your product or provide this service?
5. What are some limitations of your solution?
6. I like that you told the story of how you arrived at your solution or why it was important to you. In your pitch, I would suggest adding (some common things missing from student pitches: introduction, name of the business, description of the solution, an ending to the pitch) or changing (students often read through their slides, include too much text, etc.).
7. In my experience…. Have you thought about…

Think About It

Description:	Time Frame:	Suggested Grouping:
Formative questions to facilitate student understanding and reflection of the current phase of the challenge.	5 - 10 minutes	Individual or Small Groups

Think About It questions serve the same purpose in all phases of the challenge. See the Launch Think About It questions for a description of how to use the questions. In the Justify phase of the Transformative Structures challenge, these questions ask students to think about the Key Business Proposition and the Technical Brief, how these documents influence the design of the solution, and how the information in these documents can be useful in the final pitches. These questions include:

1. How might the Key Business Proposition influence the design of your solution?
2. How might you incorporate pieces of the Key Business Proposition and Technical Brief in your final pitch?

Additional reflection questions are included to help jumpstart student thinking. For the Justify phase of Transformative Structures, these include:

- Did your initial design change after you completed or thought about the KBP?
- Did you think about the consumers in your initial design? If not, how did thinking about the consumers help you change your solution?
- How did thinking about enhancing likes influence your solution?
- How did thinking about fixing dislikes influence your solution?
- What parts of the Key Business Proposition might investors want to know or hear?
- What parts of the Technical Brief might investors want to know or hear?
- How does the Key Business Proposition (or aspects of it) show the value of your product?
- How does the Technical Brief (or aspects of it) show the value of your product?
- What parts of the Key Business Proposition or Technical Brief would convince you to buy or invest in this product?

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The final phase of the competition is the Pitch. As students develop their pitches, they should be thinking about how they want to convince investors that THEIR solution should be funded. They should use the information they gathered/created in the previous phases, but that does not mean that they are "done" with those parts of the challenge. They may find that they need to change things about their Key Business Proposition, Technical Brief, or solution design as they think about their pitch. That should be encouraged, since this is an iterative process that is intended to reflect the real world practices of entrepreneurship.

How to Build a Pitch

Description:	**Time Frame:**	**Suggested Grouping:**
Students learn about the important components of a pitch.	Total: 30 minutes Introducing the Resource: 10 - 15 minutes Using the Resource: Students will refer back to this document as they develop their pitch. Practice Pitch: 15 - 20 minutes	Small Groups
Key Vocabulary: Pitch, competitor, customer, consumer		

Once your students have designed and refined their solutions, it is time for them to pitch their ideas to the investors. As students begin to build their pitch deck (i.e., the slides they will use to present their solutions to the judges), it will be useful for them to review this How to Build a Pitch document, as well as the Pitch Judging Rubric. You might need to help your students understand what should and should not be included in the pitch. You can do this by asking probing questions as your students are developing and practicing their pitches. For example, if students are struggling to describe the problem

that they are trying to solve, you might ask them why their solution matters or what good their solution does for their community. For students who are struggling to describe their solution efficiently, you might ask them to list their top three favorite features or aspects of their solution and explain why those features are important.

The Practice Pitch

It is important for students to practice their pitches before they do the final pitch for several reasons. First, it gives them a chance to receive feedback on their pitches, their pitch decks, and their solutions. Whether you have them present to their peers, to community members, or to you, the feedback they receive will help them make final changes to both their pitch and their product before pitching to investors. Second, it gives them an opportunity to practice defending and justifying their solutions, which can help them gain clarity on their solution and confidence in their expertise. Third, it gives them a chance to iron out any wrinkles in the presentation, including timing and who is saying what. Finally, it allows them to practice in a low-stakes environment. Many students will be nervous, so they can use the practice pitch to work out their nervous habits, like playing with their hands or swaying while speaking. To help prepare external judges, consider giving them the “Tips for External Judges during the Practice Pitch and Expert Check-Ins” included in the Justify section above.

Using this Challenge with Other Audiences

While it is important for students to pitch their ideas to the panel of investors, this part of the challenge can be done in many different ways. Many teachers have students use technology, like Google Slides or Powerpoint, to build their pitch decks and then present with that tool. Students are also welcome to make flip charts or other visual aids to present their pitches. Some teachers will have their students pitch live, while others will have their students record and submit their pitches. As with the rest of the Design & Pitch materials, we want this to work for your students, so feel free to adjust the pitch as necessary.

Teacher Tips

We often ask younger students how they would convince their parents to buy the product for them, but it also works with older students.

The pitch, especially setting up the why (the problem they are trying to solve), is where a picture is worth a thousand words. Encourage students to tell this story visually instead of writing the problem out on their slides.

Students often miss out on the opportunity to boost their product by pointing out the flaws in their competition. Encourage them to think of similar products on the market and how their product is better. If they can't think of why their product is better, you might encourage them to revisit their Key Business Proposition and figure out how they can make their product better than similar products.

When explaining how the product works during the pitch, it should be an overview of the product. Students should not be walking investors through minute details about how they arrived at the final product. Instead, they should use this time to explain the big picture of how their product works.

Example Pitches

Description:	**Time Frame:**	**Suggested Grouping:**
Students can use these sample pitches to determine what they do and do not want to include in their pitches.	10 - 30 minutes	Small Groups or whole class

Students have access to three example pitch decks from existing companies (Air BnB, YouTube, and Podozi). These are meant to serve as idea-generating examples, not templates, for the students to use to understand what a pitch *can* look like and how important elements can be incorporated into a winning pitch. Once students have developed their initial pitch decks, they should practice the pitch before delivering it to investors. This can take a variety of forms, including having teams pitch to one another, to the whole class, or to a single individual (e.g., teacher, administrator, or community member). This is a time for the students to receive critical feedback so they can develop their ideas more completely before the final pitch.

Students can watch the pitches in the following videos to learn more about what works and what doesn't work in a quick pitch. If you choose to use these videos, you can have students compare and contrast 2-3 of the pitches to decide what they liked and what

they did not like about each one. This discussion might help them determine what they want to include in their pitches and what they want to leave out.

Sample Pitches:

- Storyify: This student pitches an app that explains middle school science concepts through stories and games.
- Ball Out: This student pitches an app that helps kids find local games of pick-up basketball.
- Simple Starters: This student designed a set of conversation starter cards to help families connect at dinner.

Pitch Judging Rubric

Description:	Time Frame:	Suggested Grouping:
Students are given the criteria for judging their pitches.	Introducing the Resource: 5 - 10 minutes Using the Resource: Varying time frames throughout the challenge as students use the resource to inform their pitches and pitch decks.	Individual, pairs, or whole class

Presenting the pitch is one of the most exciting parts of the competition for students (and teachers). All of the hard work each student has put in up to this point culminates in this persuasive presentation. As a standard rule, students only have five minutes to pitch their solution to the panel of judges (more on the judges below), though you, as a teacher, have control over how long students have to present. The suggested five minutes encourages students to be succinct and helps them to become effective communicators.

In addition to overall winners, we encourage you to assign superlatives to all teams, such as awarding Best Business Design, Most Creative Solution, Best Pitch or Most Engaging Pitch, Overall Best Solution.

Preparing a Panel of Judges

Students love the opportunity to share their work with people external to the classroom. In the past, we have seen panels of principals, parents, community members, college professors, and other experts from the field. For Transformative Structures, you might consider members of your community who have experience working in fields that relate to making spaces and structures adaptable, like engineering, architecture, or construction, to name a few. To help your judges prepare for their role, provide them with some background info, such as a link to the challenge website, and the Pitch Judging Rubric ahead of time so that they can understand what they are going to be judging. The “Tips for External Judges during the Practice Pitch and Expert Check-Ins” can also be given to judges and practice judges.

As for grading the pitch, some teachers use the Pitch Judging Rubric to assign a grade, some develop their own method for scoring the pitch, and still others choose not to assign a grade to this part of the Challenge. We encourage you to think about what works best for your classroom and assessment practices.

Think About It

Description:	**Time Frame:**	**Suggested Grouping:**
Formative questions to facilitate student understanding and reflection of the current phase of the challenge.	5 - 10 minutes	Individual or Small Groups

Think About It questions serve the same purpose in all phases of the challenge. See the Launch Think About It questions for a description of how to use the questions. In the Justify phase of the Transformative Structures challenge, these questions ask students to think about the pitch resources and how the information in these documents can be useful in designing their final pitches. These include:

1. How can the pitch judging sheet help you improve your pitch?
2. Now that you have completed your practice pitch, what changes will you make to your pitch?

Additional reflection questions are included to help jumpstart student thinking. For the Justify phase of Transformative Structures, these include:

- Which part(s) of the judging sheet were you surprised to see? Which part(s) were you not surprised to see?
- Are there some parts of the judging sheet that you think the judges might care more or less about than others? If so, which ones, and why?
- Now that you've seen the judging sheet, are you going to make any changes to your pitch?
- What feedback did you receive during your practice pitch? How can you incorporate that feedback into your final pitch?
- Were you surprised by how much/little time it took to give your pitch? How can you streamline/add to your pitch to better use the allotted time?
- Did your audience seem hooked by your presentation? If not, how can you make sure you grab and keep their attention for the final pitch?

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