Unit 5: (Structures):
Stable Structures–Pigsworth Construction Company[1]

Concept Structures need to be in equilibrium with forces in order to be stable.

Content Objective Students explore with simple structures and design stable structures that do not blow over in heavy winds.

Language Objectives Students will listen and write ideas from classroom discussions using grade-level vocabulary
Students will expand their receptive vocabulary with technical words like: Design brief, specifications requirements, labeled sketch, structure, distance, fan speed and constraint.

Standards

- **NGSS**
  - **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define problem that can be solved with a new or improved object or tool.
  - **K-2-ETS1-2.** Make a drawing or physical model to illustrate how the shape of an object helps it to solve a problem.
  - **K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses.

- **TEKS**
  - **3C** Represent the natural world using models and identify their limitations, including size, properties, and materials
  - **6B** Demonstrate and observe how position and motion can be changed by pushing and pulling objects to show work being done such as swings, balls, pulleys, and wagons

- **ELPS**
  - **3H** Narrate, describe, and explain with increasing specificity and detail as more English is acquired.
  - **4F** use visual and contextual support and support from peers and teachers to read grade-appropriate content area text, enhance and confirm understanding, and develop vocabulary, grasp of language structures, and background knowledge needed to comprehend increasingly challenging

[1] NOTE: Thanks to Paul Wayne of Round Rock ISD, the first DTEACher to use the story of the Three Little Pigs as the context for this design challenge.

language
- **5G** Narrate, describe, and explain with increasing specificity and detail to fulfill content area writing needs as more English is acquired.

Tools Materials	Construction materials for structures: white copy paper to be rolled and taped; toothpicks and connectors (e.g., clay, playdough); spaghetti noodles and masking tape; straws and paperclips; construction paper; table or floor fan Handouts **3.5.1-3.5.4**
Literature Connections	*The Three Little Pigs, Building a House* by Byron Barton *How a House is Built* by Gail Gibbons

Day 1: Engage/Explore

Teacher Says/Does	Student Says/Does	Language requirements
1. Ask students to share their recollection of the story of the *The Three Little Pigs.* Have students retell the story. Discuss the structures of the three houses the pigs made. Distribute handout **3.5.1** with questions to students and ask them to think of answers to each of the following questions: • Why was the wolf able to blow down the house that was made of straw? • What makes a material strong? • Why did they get blown over? • Which way was the force of the wolf breath pushing on the structure?	Students discuss and answer questions about the story "The Three Little Pigs"	Free-body diagram
2. Give a few minutes for discussions, and then have student pairs share their ideas with the rest of the class. Tell students to write down ideas from the class discussion and to complete answering the questions in the handout individually.	Students write answers to questions about the story	
3. Draw a simple free body diagram of a pig house and show it to students, without telling students that it is a free body diagram. Ask students to tell you the word that describes your drawing, and to give another characteristic of a free-body diagram.		
4. Ask student pairs to draw the free-body diagram (**3.5.2**) of the pig house. Ask students how they would draw the force of the wolf's breath. Complete the free-body diagram with students' ideas. Have each student complete the free-body diagram for one of the pigs' houses and share a comment about their drawing.	Students draw a free-body diagram based on the story	

Day 2: Explore/ Explain

Teacher Says/Does	Student Says/Does	Language requirements
1. Show students the design brief (**3.5.3**). Explain to them that a Design Brief is a problem for their team to solve, and that to begin solving a Design Brief problem they need to read the specifications and think about it. 2. Ask the students what a stable house needs, and adapt the design specifications in the handout based on the discussion. 3. Consider the following additional requirements: a. The pig house must be stable b. It must be standing in the same place after a wind has blown on it. 4. Show students the fan that will be the wolf breath. Have them decide with you how the fan will be placed for testing their houses (distance, fan speed, etc.) Point out to them that they want the test to be fair, that each house will be subjected to the same amount of force. 5. You may wish to add a constraint that the houses are about the same size. You can do this by saying that the "footprint" of the house be not bigger than 6" by 6" (15 cm x 15 cm). This means that the base of the house will fit exactly onto a square that size. You may also wish to have a height limitation. 6. You also should decide if the houses will need paper walls or can be just a frame. As you can see, a paper-walled house offers more wind resistance and might be moved more easily. Be sure the students help make and understand the decision about walls.	Students discuss ideas about what makes a stable house Students plan models based on the design brief	• Design brief • specifications • requirements • labeled sketch • structure • distance • fan speed • constraint

Teacher Says/Does	Student Says/Does	Language requirements
7. Organize students in pairs or groups as convenient. Give each pair/group a copy of the card with the description of the design brief. Have them read the Design Brief (in the handouts), and talk with partners or within their groups to resolve any meanings, and plan who will do the different jobs. 8. Have teams start creating a plan for their model. Tell them to make several preliminary sketches, select one, and make a labeled sketch to present to the class. 9. Let teams work on their houses and then test them.		

Day 3: Explore/Explain

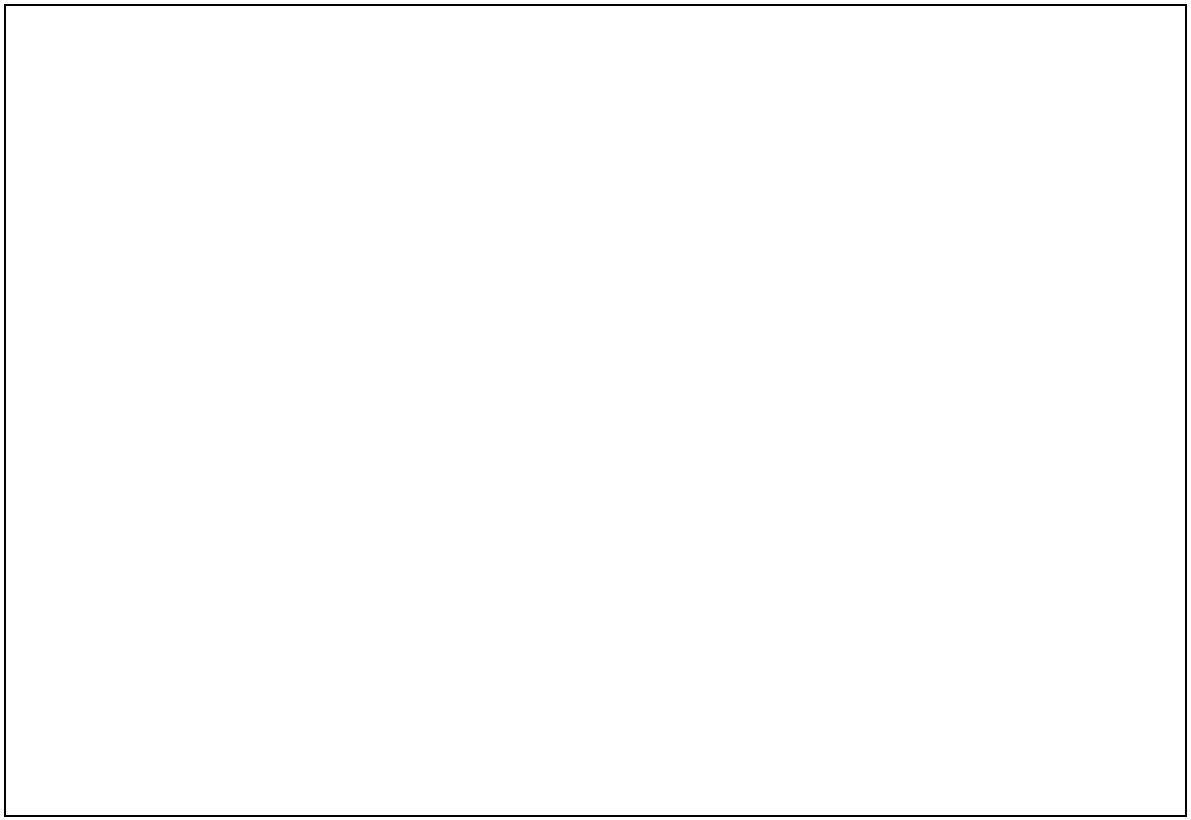
Teacher Says/Does	Student Says/Does	Language requirements
1. Have pairs or teams use a graphic organizer (see **3.5.4** for notes on our design) for writing down characteristics of their design, and the results of their testing. 2. Organize presentations from each pair of students or from each team to talk freely about their design and about the result of their testing. Have them share their ideas to the class and get feedback. 3. Here are some questions to ask during the de-briefing: a. -How stable was your pig's house during the wolf breath test? b. -What were some ideas you had that changed during the construction of your house? c. -How did your team share ideas and work together? d. -In what ways is your house a model? 4. Then have them write their ideas on the third category: Feedback from the Classroom Discussion. 5. Student teams should dictate or write a log entry that describes the project and the stability of their structures.	Students use a graphic organizer to write characteristics of a design and discuss it with classmates	

Day 4 Elaborate and evaluate

Teacher Says/Does	Practical Extensions	Language requirements
1. Ask students to remember their free-body diagrams and the discussion about the houses from the Three Little Pigs, and ask them to discuss what makes a structure stable. Have them give examples of an unstable and a stable structure. 2. Show students the materials for building simple structures, using noodles, toothpicks, paper rolls, straws, and other materials. Let them spend an hour or two making a little house out of each structural material. Ask them to build structures that are stable. 3. When they have all had some experience with a variety of construction techniques, have them share what they have learned. You may wish to focus the discussion with these questions: • Which structures are more stable? why? • Which connectors worked best with noodles? Toothpicks? Paper rolls? Straws? • Which shapes (triangles, squares, circles) seem to make structures that are best balanced—that is, they do not easily fall over?	Students share examples and non-examples of a stable structure Students participate in a discussion about stability	Stable structures Connectors

Question for pair/share	Sentence stems for answers
What makes a material strong?	A material is strong when_____
Why was the wolf able to blow down the house that was made of straw?	The house of straw could be blown down because _____
Why did they some houses get blown over?	They got blown over because_____
Which way was the force of the wolf breath pushing on the structure?	The force of the wolf breath was pushing _____

My free body diagram of the pig's house made of _____



Design Brief Description (draft)
Goal: Design and a stable house for one of the pigs in the Three Little Pigs to protect him from the wolf.
Specifications and Constraints: -The pig house must be stable. -It must be standing in the same place after a wind has blown on it. -You must use materials available to everyone. -You should draw and label your plan and present it in a design review. -You should get approval before you begin. -You should practice safety at all times.

Main Characteristics of our Design	
Results of our Testing	
Feedback from the Classroom Discussion	

Assessing the design of the model.

	To some degree	To a moderate degree	To a large degree
CONTENT			
(Used recycled material)[1]			
(Used synthetic materials)			
(Used natural materials)			
SKILLS			
(Worked well in a team)			
(Presented ideas and product to the class)			
(Participated in a design review)			
(Helps clean up)			
PRODUCT			
(The model works)			
(A drawing of the design was presented)			
(Team met the constraints of time)			
TOTAL POINTS			

[1] The criteria in parenthesis should be replaced with ideas from students.