stEm

Title: Make It Strong So the Billy Goats Can Walk Along

Grade Level: 3rd Grade

Duration: Four 45 Minute Inquiry Monday Classes

Objective: Students will design a structure (bridge) with enough strength to hold 50 grams of weight	**Focus Concept/s:** Building strong structures
Essential Question/s: How can you build a structure (bridge) strong enough to hold a defined weight?	**Connected Benchmark/s:** SC.3.N.3.3 Recognize that models are approximations of natural phenomena; such as they don't perfectly account for all observations. SC.3.N.1.7 Explain that empirical evidence is information, such as observation or measurements, that is used to help validate explanation of natural phenomena
Vocabulary: • Model • Prototype • Civil Engineer • modifications • Engineering Portfolio • Blueprint • Structure • quantitative data • qualitative data • client	**Materials:** • Design Challenge Planning Sheet • 3 index cards (4x6 size) • Gram weights • 1 stick of clay • Picture of river • Troll cut out • Construction paper for engineering portfolio (optional) • Book - *The Three Billy Goats Gruff*

Problem/Challenge (Engage):
Read the mini book provided, ''The Three Billy Goats Gruff'' (teacher can prepare books for individual students beforehand, provide 1 book per team, or get the book from the library for a read aloud)

After completing the story, provide students with the following scenario:
• It's twenty years later; the Three Billy Goats have had enough trouble with the troll that lives under their bridge. The bridge over the river is old. They want you to make a model of a new bridge that will hold the Billy Goats as they crossover it, while providing shelter

for the troll. Remember, we want don't want any more trouble from the troll! You will get three index cards and clay. Your challenge is to create a bridge that will cross the river, keep the troll covered, and hold at least 50 grams of weight without falling down.

- Explain to students that in order to complete this challenge they must become civil engineers. Go to website http://discoverengineering.org to read the career profile of what a civil engineer does. **[**Navigation directions on website: Skip the intro, go to "What's Engineering", click on "Career Profiles", scroll to find "Civil Engineering"**]**
- Group the students into teams of no more than 4. Have each team come up with a team name for their civil engineering company.
- Another option is to use the Design Challenge Planning Sheet packet and wrap it with the construction paper. **OR** have teams create Engineering Portfolio's (1 per student) using construction paper (Zike's Big Book of Science Foldables; copy included)
- Have students decorate the front cover, students will glue the RFP (Request for Proposal) on front cover.

Brainstorm/Investigate (Focus Concepts):

- To help build some background knowledge about civil engineering, students will watch the video, "The Impossible Bridge" at http://www.sciencekids.co.nz/videos/engineering/bridgebuilding.html . Discussion of video should focus on the design process, not the type of bridge being built. During the video they will see an example of a model and prototype. Also at around the 2:15 mark you see how decisions are changed based on the effectiveness of a model (this will occur for students when they design).
- Have students get in their engineering teams; show them the materials they have to work with.
- Allow time for teams to brainstorm about how they can build a strong enough bridge that is also tall enough for the Billy Goats to cross over safely.
- Have students sketch their ideas in their Design Challenge Planning Sheet or Engineering Portfolio. Title that section, "**Brainstorming**"

Plan/Design (Blueprint):

- Discuss with students the purpose for the bridge. What challenges need to be considered during planning? (Length of bridge, height of the troll underneath)
- After discussion, teams will create a blueprint drawing on their Design Challenge Planning Sheet or in their Engineering Portfolio. Title this section, "**Blueprint**". You will need to make everyone aware of the term blueprint. If you have a blueprint of your home, it would be a great resource)
- The blueprint must be labeled with the materials that are being used.

Build/Test:

- Teams will begin to develop a prototype (Discuss this word with students, refer back to the video, "The Impossible Bridge")
- Distribute the same amount of materials to each team
- Groups will first build based on their blueprint. They will test that design and collect data.

Collect/Analyze Data:

- As they are building, teams should be collecting quantitative data on how much weight their design can hold.
- Have students create a data table similar to this:

Design (sketch of Bridge)	Amount of weight (in grams)

Students can add rows to this table each time they design a better bridge than the one before.
By the end, each team will have their best prototype ready for Presentation Day.

Reflect on Improvements:

Each time a team makes changes during the testing phase they must reflect on why they are making these changes. These changes will be written in Design Challenge Planning Sheet or in their Engineering Portfolio. Title that section "**Test Modifications/Improvements"**

Evaluate/Justify: ***Presentation Day***

Each team of civil engineers will present their prototype to the class and test it.
The other teams should record data (both quantitative and qualitative) about each team's prototype.
Provide the following data table and have team glue it into their Engineering Portfolio. Title that section, "**Evaluation"**

Bridge Prototypes

Civil Engineering Company	Observations (How it is different than ours?)	Sketch of Prototype	Amou Weight (in gr

- After seeing all the civil engineering teams present their prototypes, have teams reflect what they could have done differently to improve their design. Reflections will be written it the Engineer Portfolio. Title the section, "**Reflections**"

- As a whole group, give teams one last chance to defend their bridge prototype and why it should be the one to be built to help The Three Billy Goats Gruff get across the bridge safely.

- For teams that met the challenge of creating a bridge that will cross the river, keep the troll covered, and hold at least 50 grams of weight without falling down, they will receive a design contract (presented by you; a copy is included) acknowledging a job well done!!!

Request for Proposal
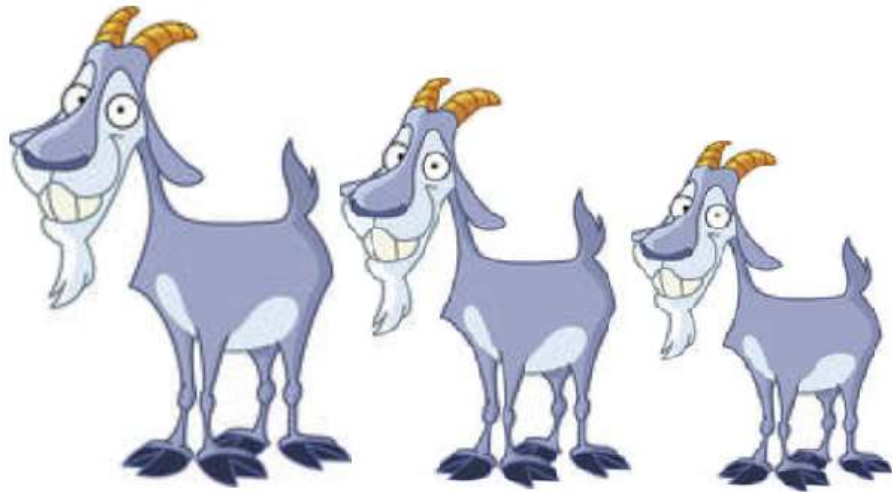
It's twenty years later. The Three Billy Goats have had enough trouble with the troll that lives under their bridge. The bridge over the river is old. They want you to design a new bridge that is strong enough to hold the Billy Goats as they crossover it while providing shelter for the troll. Remember, they want don't want any more trouble from the troll!

To win the bid, you must submit a prototype of the new bridge.

Your challenge is to create a bridge prototype that will:

- cross the river,
- keep the goats protected from the troll,
- use only three index cards and clay, and
- support at least 50 grams of weight without falling down.

Best of luck and watch out for trolls!

Engineer:_____
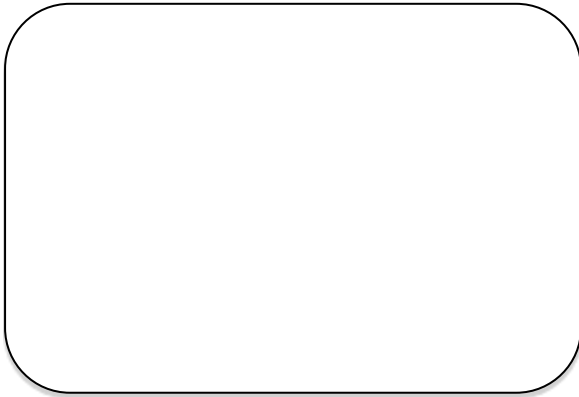
Design Challenge Planning Sheet
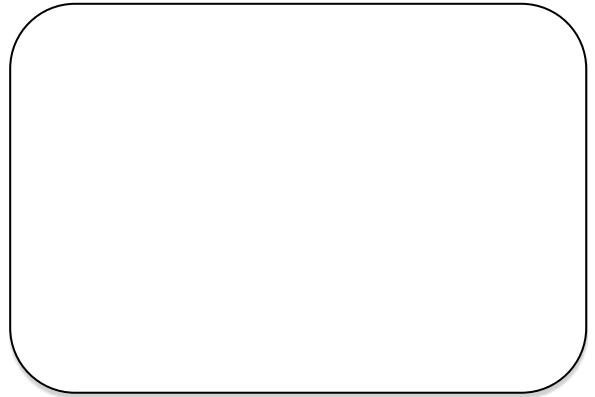
Problem/Challenge:

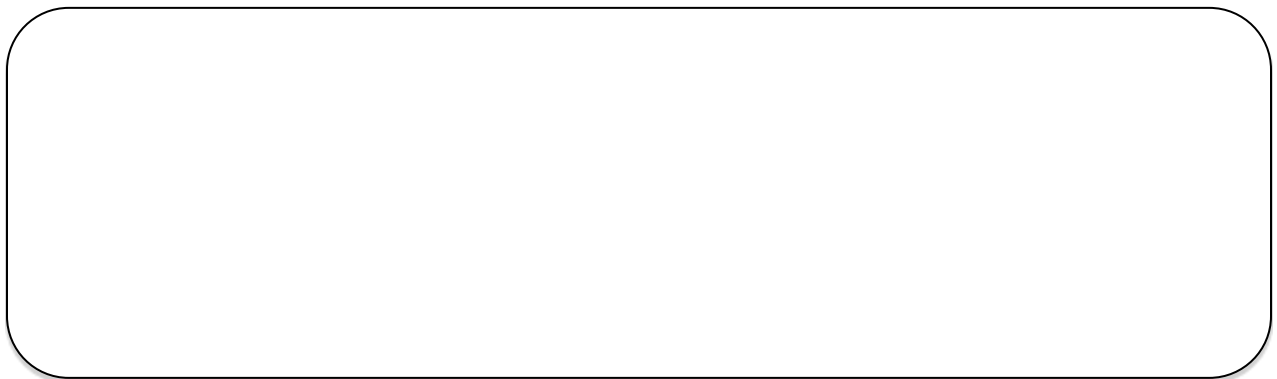*Investigate/Brainstorm: Independently, draft possible solutions.*

A.

B.

Identify the strengths and weaknesses of this design. How will it help you to complete your proposal?

Plan/Design: *Compare your design with your partner's and choose the one you want to build. Sketch your blueprint. Remember to identify materials and label your design.*

Build/Test: *Build and then test your solution.*

Collect and Analyze Data: Collect data throughout your trials.

Data Chart	
Trial 1	
Trial 2	
Trial 3	
Trial 4	
Trial 5	

Reflect/Improve: Was it the best solution? Why or Why not?

_____

_____

_____

What would you have done differently? How would you improve your design?

_____

_____

_____

Evaluate and Justify your answer. Discuss your findings with the other engineers in the classroom. Draw a conclusion using your data to justify your thoughts.

_____

_____

_____

*Use the data and collected observations to design and test a NEW prototype.*

Bound Book

1. Take two sheets of paper (8 1/2" χ 11") and separately fold them like a *hamburger*. Place the papers on top of each other, leaving one sixteenth of an inch between the *mountain tops*.

2. Mark both folds one inch from the outer edges.

3. On one of the folded sheets, cut from the top and bottom edge to the marked spot on both sides.

4. On the second folded sheet, start at one of the marked spots and cut the fold between the two marks.

5. Take the cut sheet from step 3 and fold it like a *burrito*. Place the *burrito* through the other sheet and then open the *burrito*. Fold the bound pages in half to form an eight-page book.
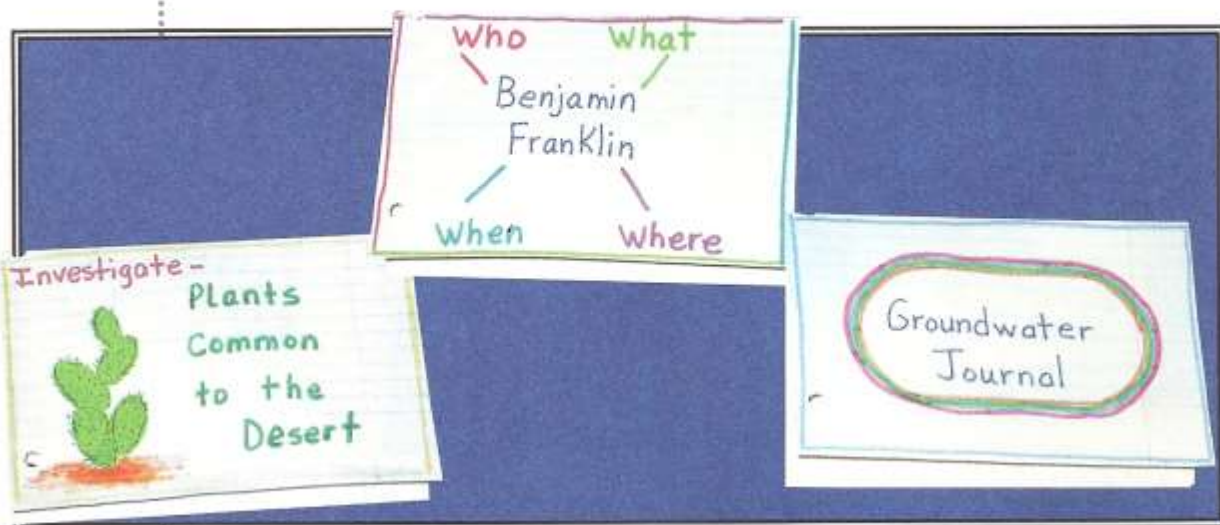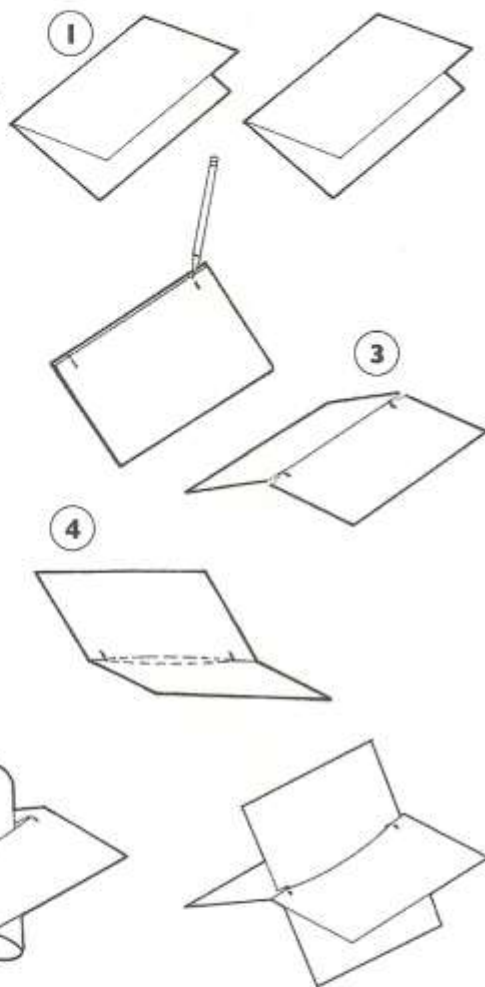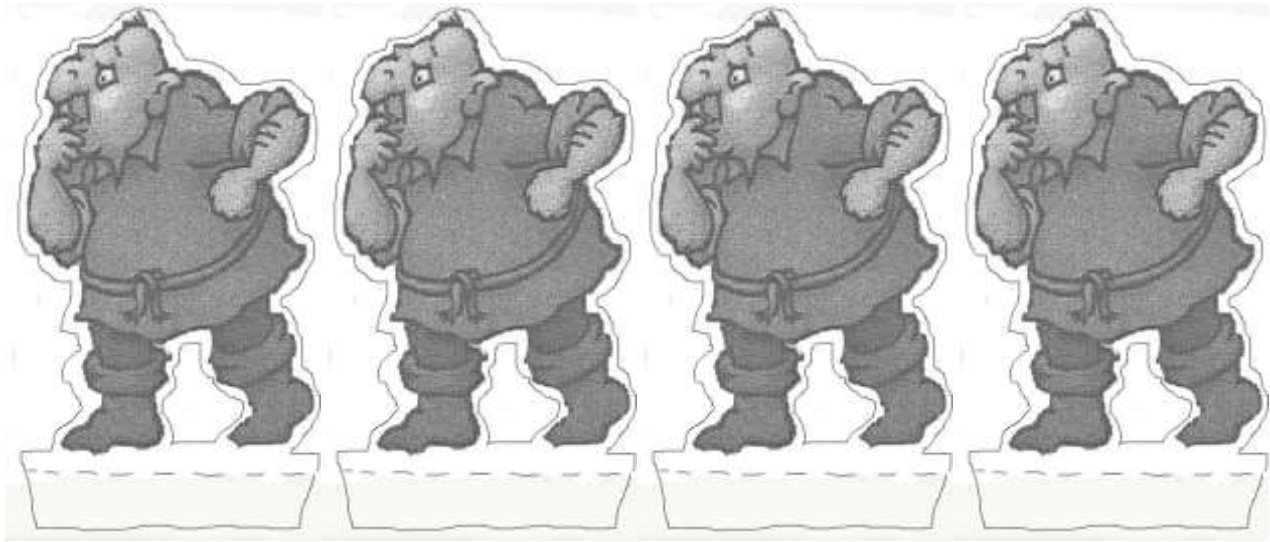
Cut out trolls for each Engineering team to use in their bridge models. The troll must fit underneath the bridge.

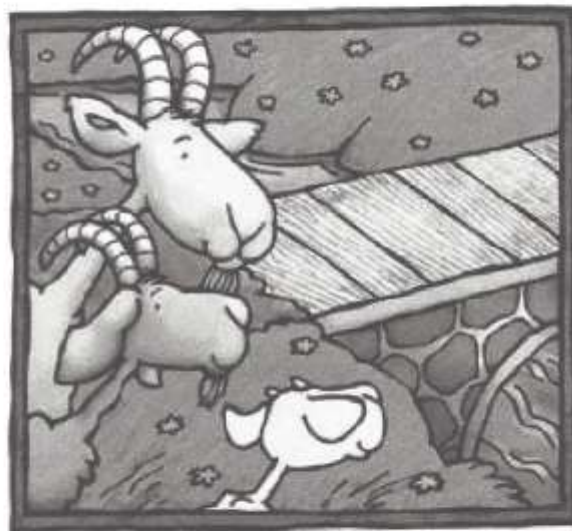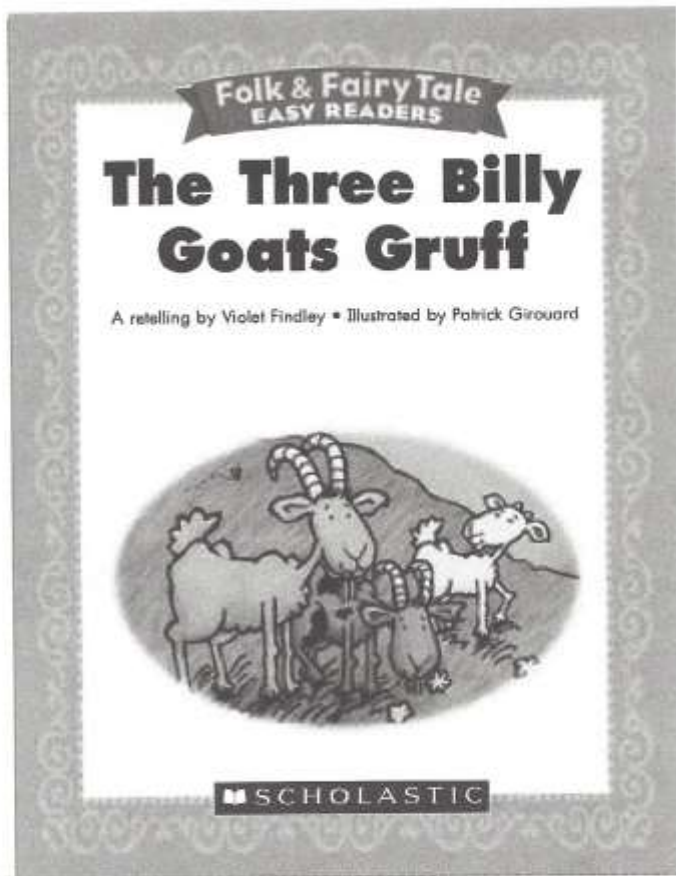# BUILDING BRIDGES
River Crossing

After that, the three brothers crossed the bridge whenever they liked. And, my, the sweet green grass was delicious!

16

Folk & Fairy Tale
EASY READERS

The Three Billy Goats Gruff

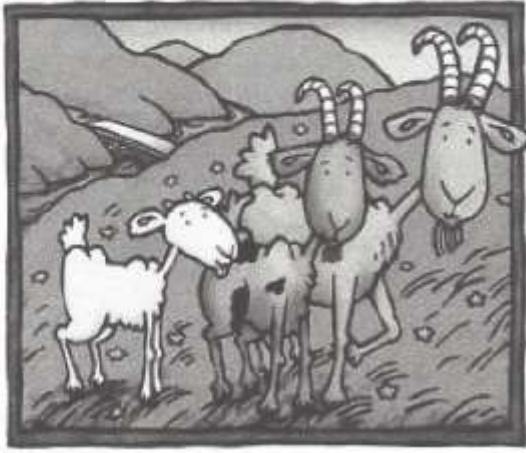A retelling by Violet Findley • Illustrated by Patrick Girouard

SCHOLASTIC

"Stop there! I am going to eat you up!" yelled Troll.
"OK," said Big Billy, for he had a sneaky plan.

14

One day, they decided to cross the bridge to eat the sweet grass on the other side.

3

Once upon a time, there lived three billy goat brothers. Their names were Little Billy, Middle Billy, and Big Billy.

2

A

There was only one problem. A mean troll lived under it.

4

B

When Troll climbed up on the bridge, Big Billy rammed him so hard that he fell into the water with a giant splash!

15

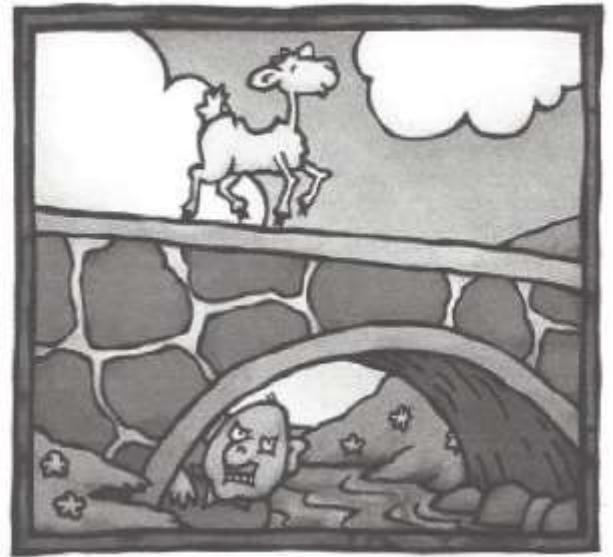Clomp, clomp, clomp! Big Billy started across the bridge. Then he heard a cranky voice.

13

"What a fine idea," said Troll, licking his lips. And with that, Middle Billy crossed the bridge.

12

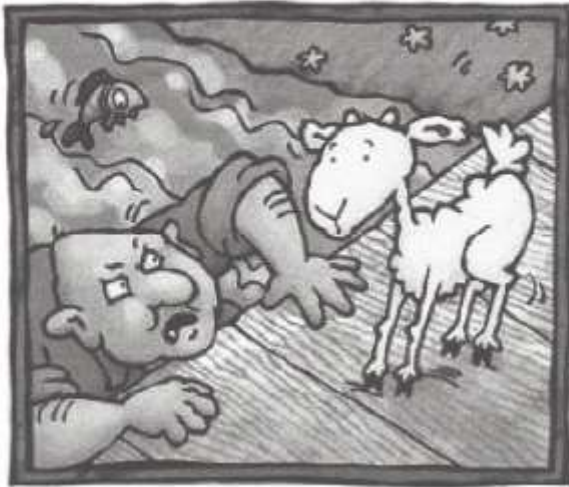Clomp, clomp, clomp! Little Billy started across the bridge. Then he heard a cranky voice.

5

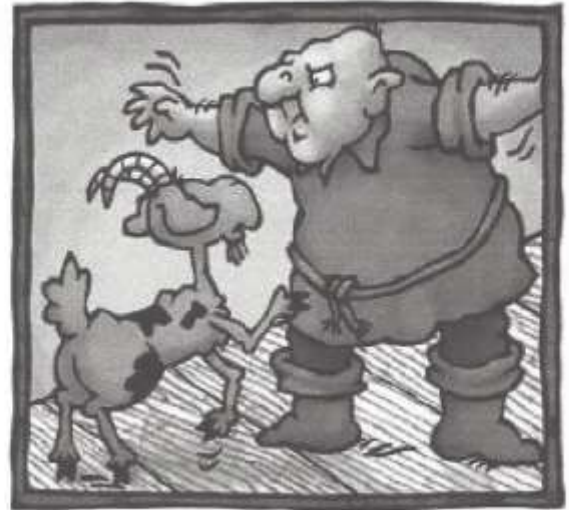"Stop there! I am going to eat you up!" yelled Troll.

10

"Wait for my brother. He is bigger and much more delicious than I!" cried Little Billy.

7

"Stop there! I am going to eat you up!"
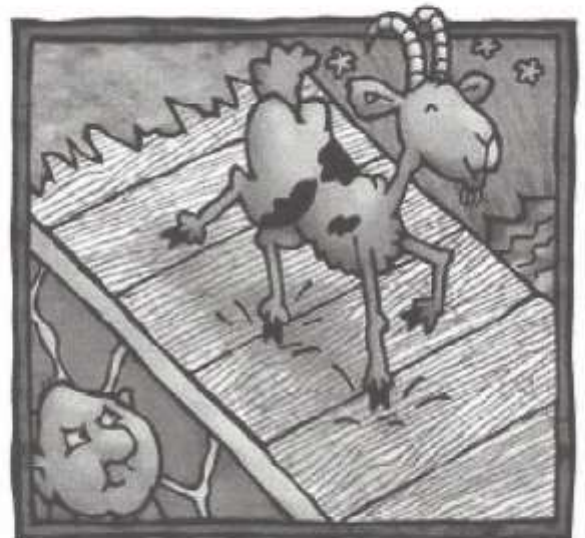yelled Troll.

6

"Wait for my brother. He is bigger and much
more delicious than I!" cried Middle Billy.

11

"What a fine idea," said Troll, licking his lips.
And with that, Little Billy crossed the bridge.

8

Clomp, clomp, clomp! Middle Billy
started across the bridge. Then he heard a
cranky voice.

9

C

D

Three Billy Goats Corporation

This certifies that _____ has

been awarded the contract to build the Troll River Bridge.

In Witness Whereof, the said Corporation has caused this

Certificate to be signed by its duly authorized officers and its

Corporate Seal to be hereunto affixed this _____

of _____ A.D. _____

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