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Mathematics Festival®

River Crossings
Leading the activity online

Materials
River Crossings app
River Crossings Desmos (Sign into your account and create a copy.)
1 device per student is optimal, preferably no cell phones

Learning Goals
- Develop logical reasoning skills.
- Develop flexible strategies that accommodate changes in constraints.
- Develop the ability to plan ahead by anticipating the result of potential moves.
- Distinguish between impossible and difficult.

Engage
Before showing the app, let the students know that River Crossings is an old puzzle, first written about over 1000 years ago! As in the original puzzle, the goal is to ferry a wolf, a goat, and a cabbage safely across a river.

Share the app on your screen. Skip the tutorial and start with Puzzle 1.

Explain how to select the items and make the boat move while demonstrating taking the cabbage across first (the wolf then eats the goat!). Then try taking the wolf (the goat then eats the cabbage!). Ask for suggestions about what you could try next. Solve the initial problem together, which will take 7 crossings.

Initiate
Introduce the second puzzle. Ask for suggestions on what moves to make.

Puzzle 2 is an impossible puzzle so, when they begin running out of things to try, ask: *Are you beginning to think this puzzle might be impossible?* (There is a blue *Impossible?* button, but don't select it.) Instead, ask the students to try it for themselves and decide.

Demonstrate how to access the Desmos and how to enter answers.

Create groups (*see below). Send links for the app and for the Desmos.

Extend:
Students who complete the goat, wolf, and cabbage puzzles are encouraged to explore the next scenario - Zombies - found by clicking the grey gear on the bottom right.

*Creating Groups

1. Classroom teacher - all students are physically present

a. Groups of 2
       Have one student open the app on their screen and the other student open the Desmos.

2. Classroom teacher - students are online or hybrid
    a. Groups of 2 in breakout rooms
       Both students will have both links open, but have one student share their screen and then work together to complete the Desmos.

3. Online Festival - all students are online
    a. Groups of 4 to 6 in breakout rooms with one Activity Leader (AL) Depending on the experience of the group:
        i. The AL might screen share or ask one of the students to share.
        ii. The AL may ask the students to explore a puzzle independently for a few minutes and then share their findings. They can complete the applicable Desmos question together before trying the next puzzle together or independently.

We encourage the use of Desmos as it captures students' thinking as they problem solve.

Desmos Questions and Answers

1. Try puzzles 1 and 2. One of these two puzzles is impossible. What makes it impossible?
   ● Puzzle 2 is impossible because, if you can only carry one item at a time, you can't have more than one goat. It would work if there was only one wolf or only one cabbage.

2. Try puzzle 3. Was puzzle 3 possible or impossible? Why do you think puzzle 3 is easier to figure out than puzzle 2?
   ● Puzzle 3 is possible. It's easier because you can take all of one item (goats or non-goats) at the same time.

3. Try puzzles 4, 5, and 6. Which of these three puzzles was the hardest to solve? What made it so hard?
   ● The fourth puzzle is the hardest because once they discover the strategy (carry the non-goats back and forth each time), they can apply it to Puzzle 5. Puzzle 6 is impossible.

4. Try puzzles 7 and 8. What strategy did you use to solve puzzles 7 and 8? How would you explain this strategy to a friend?
   ● You can move one goat at a time by keeping the wolf & cabbage on the boat at all times.

5. Make a prediction. This puzzle isn't in the app. Can you predict if this puzzle is possible or impossible before trying to solve it? If you think it's possible, how

would you solve it? If you think it's impossible, how would you explain why to a friend?
  - It is possible because you can keep the wolf and cabbage on the boat the entire time and move one goat at a time.

6. Try puzzles 9, 10 and 11. What strategy did you use for these puzzles? If you needed to change your strategy from previous puzzles, how did you do so?
   - Puzzle 10 is impossible. For puzzles 9 and 11, the strategy is to move the two goats back and forth each time.

7. Make a prediction Pt. 2. These three puzzles aren't in the app. One of these puzzles is impossible. Without trying to solve them, can you predict which of these three puzzles, Option A, B, or C, is impossible? Why do you think it's impossible?
   - Option B is impossible. If you have 3 goats, you can only bring a maximum of 6 non-goats.

In general:
- 2 items: You can have 1 goat and any number of other non-goats.
         You can have 2 goats and take a maximum of 4 non-goats.

- 3 items: If goats or non-goats equals 3, then you can have 6 of the other.
         If either goats or non-goats are less than 2, you can bring any number of the other.

- For any number of goats and non-goats, the boat must be able to hold either the number of goats or the number of non-goats, whichever is smaller.