

Logic Puzzles: Sudoku

Grade Level

This activity is intended for high school students.

Outline

The purpose of this activity is to introduce the main moves of any logic puzzle: forced moves, implied moves, and guess-and-check moves, by using Bridges and Sudoku as a template. After the introduction we will probe deeper questions about logic puzzles and possible generalizations via Sudoku. Then we will create our own generalizations using Shidoku as a base.

Materials

- One Sudoku puzzle
- Four Shidoku puzzles
- Eight to Ten Bridges puzzles
- Pencils/pens
- 1 foot lengths of rope, enough for 8 per student.
 - This will also work if the amount of rope you have is equal to the total number of bridges in the puzzle or equal to the numbers on each island.
- Printer paper or paper plates with numbers on them

Bridges Activity

Bridges is an activity where there are islands connected by bridges. The rules to Bridges are as follows:

1. Each island has a number which represents the exact number of bridges connecting it to the other islands
2. An island can only be connected to an island which is above, below, or to the left or right.
3. There can be 0, 1, or 2 bridges connecting any appropriate pair of islands.
4. The bridges should be placed in such a way that you can “walk” between any two islands in the puzzle by a series of bridges.

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There are many web resources for finding Bridges puzzles, such as:

<http://www.puzzle-bridges.com>
<http://www.brainbashers.com/bridges>.

After a quick introduction to Bridges, try this group activity. Prior to the class, generate a bridge problem using one of the above resources and print the puzzle. With a puzzle(s) in hand, jot the numbers down on printer paper (or paper plates) to represent the islands. Be sure there you also have enough string/rope to give to the students, as the string/rope will be the bridges. Now in class, each student will represent an island and be given 8 bridges to connect themselves to their fellow classmates and a paper (or plate) with a number on it. Each student is given more than enough bridges to complete the activity and will need to work together to complete the puzzle. If you have more students than islands you can employ one or two students to be helpers to make sure that everyone in the puzzle is following the rules. Now, you can organize them based on the layout of the puzzle you printed. It is up to the students now to determine how to connect themselves to each other.

After the group activity, break the students up into small groups and have them complete several bridges puzzles of increasing difficulty. Difficulty can be based on the number of islands, the location of islands, the numbers on the islands, etc. Let the students work on them for about 10-15 minutes then go to the group activity.

The group activity combined with the bridges packet is a jumping point to talk about the main strategy for solving puzzle games. These moves are:

- **forced moves** - as the puzzle forces you to make from the initial conditions,
- **implied moves** - moves that are revealed after initially solving the forced moves,
- and simple guess-and-check if there are no other moves.

After discussing with the students these three types of moves, have them complete one more bridge problem (small group puzzles) labeling the different moves (different colors) that are made.

Sudoku and You

Come back as a group and give a quick introduction to Sudoku if no one is familiar. Using an example puzzle, the harder the better, show the students some forced, implied, and guess moves for the Sudoku puzzle. This exemplifies how the methods used previously for the Bridges translates to Sudoku exactly as defined. In fact, the defined moves apply to all logic puzzles!

Now, break the students into small groups and task them with determining relevant aspects of completing Sudoku puzzles. These can vary between references to the rules, changing the size of the grid, etc. At this point, it may be useful to define some language when discussing Sudoku puzzles:

- A Sudoku board is a 9x9 grid where the numbers 1 to 9 are repeated in every row, column, and 3x3 block.
- A Sudoku puzzle is a partially filled in Sudoku board that can be completed in exactly one way.

After the discussion, have the students focus on the following questions"

1. How many Sudoku puzzles are there?



2. What is the minimum number of clues that a Sudoku puzzle can have?

At this point, introduce the student to Shidoku as a method of simplifying those questions. Shidoku is a 4x4 simplification of Sudoku and can be used to come up with a general strategy to answer advanced Sudoku questions

Shidoku as Sudoku Lite

The rules of Shidoku are the same as Sudoku, however it is limited to the numbers 1-4. While Shidoku puzzles are easier, it allows for students to come up with strategies for answering the above questions with much more manageable numbers. To get a feel for Shidoku it will be helpful to first have a full class activity in the same vein as Bridges with either the packet or a full group Shidoku puzzle. Then separate the class into groups of 4 or 5, and hand out three to four sets of Shidoku puzzles with decreasing numbers of clues with the final puzzle having 3 clues. The idea is to show that the minimum number of clues necessary to solve a Shidoku puzzle is 4 clues and hopefully the groups will come up with different Shidoku boards with the 3 clue puzzle. Then in those groups, have the students discuss how one would count the number of Shidoku boards, NOT puzzles (no clues yet), to see if there is a method that can generalize. Refer to the following websites for explanations to the number of Shidoku boards and minimum number of clues necessary:

<http://theory.tifr.res.in/~sgupta/sudoku/shidoku.html>

http://sudopedia.enjoysudoku.com/Shi_Doku.html

With various methods in hand, discuss the current answers of these questions done by mathematicians. For your reference:

- In 2005 mathematicians Felgenhauer and Jarvis used a computer to find that there are 6, 670, 903, 752, 021, 072, 936, 960 different Sudoku boards. As a contrast, there are 288 different Shidoku boards.
- In 2012 it was found, again by computer, that the minimum number of clues necessary for a Sudoku puzzle is 17. This was done by finding equivalences in Sudoku boards and testing a number of 16 clue puzzles to see if they generated a unique solution.

From this have the students work in pairs or groups of no more than 4 to come up with a new type of Sudoku with additional rules and see if there is a Shidoku version which can answer our two main questions about Sudoku. In this case, working with the Shidoku first will be more beneficial than working with the Sudoku. Limitations or extra rules can include:

- Having the numbers 1-9 appear on the main diagonals
- “Worms” - On the Sudoku grid there are ovals over certain connecting squares, and inside each worm the numbers inside must increase or decrease. So in a worm that covers 4 squares the sequence 1394 is not allowed, but 8421 is.

UNIVERSITY of HAWAI‘I
MĀNOA



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