Technology
Arts Sciences
TH Köln

FEMSTEAM MYSTERIES: STEAM SCENARIO TEMPLATE

Title

I want to be a programmer!

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Summary

Over the last few years, the need to strengthen the sectors that support the fourth industrial revolution and the transition to Industry 4.0 has become evident. New technologies such as artificial intelligence and robotics will be essential in the near future, for which there is a shortage of professionals. Programming and STEM areas are key to lead this new industry.

This scenario aims to favour the incorporation of girls in STEM skills to enhance gender equality in studies and professions related to programming, robotics and computational thinking, as well as to enrich technological projects through different perspectives.

Gender stereotypes towards some STEM areas and towards programming and robotics in particular, present in boys and girls from very early ages, generate less interest and confidence in girls and reduce their presence in engineering and computer science related careers.

Computational thinking helps them, regardless of their gender, to understand what aspects of a problem can be solved through technology, so that they are able to adapt a technological tool to a different use than the original one and to extrapolate this methodology to any problem in everyday life.

The tools used in the scenario also contribute to motivation, develop critical thinking and stimulate creativity. To achieve the objectives, it will be necessary to apply communication skills in teamwork, as well as perseverance when facing mistakes in problem solving.

The driving question is: What makes me a good programmer?

Subjects

- Technology provides students with the knowledge necessary to get started in programming and computational thinking. It develops the student's vision towards engineering and how science and technique help us to solve problems of everyday life to make it easier for us. Block programming provides a framework for developing and for assessing computational thinking through a creative approach to teamwork in the context of design-based learning.

  The scenario requires previous work with scale, dimensioning and representation in two and three dimensions.

- Mathematics will help them in the approach of solving problems and dividing them into ordered sequences of phases for the elaboration of algorithms and flowcharts, through the pattern recognition for decomposition of complex problems. In fact, this particular scenario is closely linked to one of the specific competencies that the new Spanish education law develops for the subject: "*Using computational thinking, organising data, decomposing into parts, recognizing patterns, generalising and interpreting, modifying and creating algorithms in a guided way, to model and automate situations of everyday life." (LOMLOE 2022)*

  In addition, this scenario requires previous work in the subject areas of plane geometry and space geometry.

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Real- life questions

The real-life questions that students will attempt to respond to, driving from "*What makes me a good programmer?"* are:

- How do computers work?
- How are computer games and apps made?
- Is programming a boring/difficult job?
- What does a programmer do?
- Is programming a male profession?
- What do I need to learn to become a programmer?

Aims of the scenario

The scenario aims:

- *to help students to value and respect the gender difference and the equality of rights and opportunities between them,*
- *to reject stereotypes that discriminate between men and women,*
- *to develop students' key skills in the use of information sources in order to acquire new knowledge with a critical sense,*
- *to conceive scientific knowledge as a STEAM integrated knowledge, which is structured in different disciplines, as well as to know and apply the methods to identify problems in the different fields of knowledge and experience,*
- *to develop entrepreneurial spirit, participation, critical sense, personal initiative and the ability to learn to learn, plan, make decisions and take responsibilities,*
- *to help students understand that computers do what we tell them to do and that programming is therefore a communication task.*

Connection to STEAM careers

The students would develop critical and creative thinking about FemSTEAM role-models and careers, and to disassociate the skills needed to perform these tasks from their gender.

Age of students

14-15 years old

Time

Preparation time: 2 hours

Teaching time:

- **Preparation: 1 hour**
- **STEAM Mathematics: 1.5 hour**
- **STEAM Technology: 10.5 hours**

Assessment time: 2 hours

Teaching resources (material & technological tools)

Materials:

Computers

Unplugged games worksheets

Online tools:

FemSTEAM Mysteries game

MIT Scratch

21st century skills

This educational scenario will enhance among the students the following skills, defined as 21st century skills:

- Collaborative work will help to increase student's competence in linguistic communication, because students should interact in oral and written form in a coherent appropriate manner for different communicative purposes: argue their opinions in the creative resolution of the unplugged games, express their evaluations about the strengths and possible improvements of the *FemSTEAM Mysteries* game, effectively elaborate the orders that will form the different algorithms for the resolution of proposed technological problems and present their work to the rest of their classmates.
- Mathematical competence will be developed through the problem-solving skills to break down the problem into sequential steps that allow its resolution.
- Technology and engineering competence will be enhanced as the students build their critical thinking skills through the analysis of computational thinking and the ability to solve problems in a creative and collaborative way, thanks to the abilities developed through the use of block programming for design-based learning.
- Digital competence will be enhanced when using the Internet to critically search for previous solutions to similar problems and investigate other options that awaken their curiosity towards the possibilities of the tools used.
- Concerning civic competence, this scenario aims to make students aware of their capabilities in developing tasks related to the STEAM careers in a fun enjoyable way. They will have to work on their dialogue and teamwork skills, regardless of their gender, in order to achieve creative solutions to initially complex problems.
- The entrepreneurial competence will be developed at the same time as increasing the creative thinking when designing their game taking into account the considerations drawn from the previous analysis of the *FemSTEAM Mysteries* game in terms of gender equality approach and gameplay.
- The competence in cultural awareness and expression will be developed through the understanding and respect of how the ideas, opinions, feelings and emotions about gender equality in STEAM are expressed through the game design.

Teaching approaches and learning strategies/theories

List and justify the main teaching pedagogies and strategies you will apply and their relationship to the FemSTEAM Mysteries role-model game-based approach to gender equality in STEAM.

Educational scenario

Name of activity	Procedure	Time
1st Lesson: Motivation to the project		
Brainstorming and discussion	Brainstorming and discussion on how a computer works, and who makes the programs, games and applications that we use in our daily lives.	15’
Discussion and preparation for the next lesson	A series of images of male and female programmers are projected and the students are asked which of these people they think are programmers. Among the images, stereotypes of scientists and programmers will be shown, such as old white men, and girls (as Lucía Sánchez, CEO of Unicorn Gamer or Samaira Mehta, CEO of CoderBunnyz) who are actually game programmers and who are similar to them in age and physical appearance or interests. After the correct answers are revealed, they will be asked to reflect and discuss what it takes to become a programmer, after which they will have to write down their opinion on the following question: *What do you think is necessary to become a programmer?* *Despite their physical appearance, nationality, age or gender, what do these people have in common?*	30’
2nd Lesson: The maths recipe		
STEAM Mathematics	Cooking can be an ally in mathematics. It is useful when we bring the concept of proportion to everyday life and can also help us with algorithms. In pairs or groups of three, students must establish the orderly and objective step-by-step of different actions in the kitchen, such as frying an egg or preparing a sandwich. Then, they should repeat the action with more complex processes, such as the elaboration of the algorithm of mathematical operations. *What would happen if we changed the order of the steps? Could we solve the problem? Can we represent it in a simple way?* We work in the use of flow charts.	90’
Learning products	Cooperative construction of an algorithm and its flowchart.	
3rd Lesson: Computers are dumb		
STEAM Technology	Computers need us to tell them what to do through instructions called algorithms. We can't talk to computers because we don't know their language, but we can better understand how they work through unplugged games. Students will be asked to solve a series of team games that develop computational thinking. (See *Annex I*) The games are designed to develop analysis, logical thinking, algorithmic thinking (Boolean logic, loops, information processing),	60’

Name of activity	Procedure	Time
	decomposition, abstraction, debugging, solution validation and pattern recognition. Students will work in a cooperative and fun way on how computers follow simple strategies for solving complex problems. They should explain the solution adopted and write a conclusion about what they have learned.	
Learning products	Solutions to the games and conclusions or observations thereon.	
4th Lesson: Playing the *FemSTEAM Mysteries game*		
STEAM Technology	Students should play the *FemSTEAM Mysteries game* in pairs or groups of three to analyse its gameplay. From the user's point of view, they should express what they like most about the game and the difficulties encountered in the different rooms. Then, they will have to answer a form about their impressions of the game.	90´
Learning products	Google form answers on the *FemSTEAM Mysteries game.*	
5th Lesson: Programming a game		
STEAM Technology	Scratch is a block programming tool that allows us to program without knowing complex programming languages. Using the Scratch tool and taking into account what they learned about gameplay in the previous session, the students will have to program a game in pairs or in groups of three. They will only be assisted by the teacher for basic instructions on movements and actions. They should work cooperatively and discuss the best ways to solve problems as they arise.	6 hours
Learning products	Cooperative design of a Scratch game.	
6th Lesson: Presentation of the game		
STEAM Technology	Presenting the game to the classmates and describing it. Students should describe the scenarios and the objects or characters chosen in their game. They will then explain the code showing the algorithm of each of the elements and demonstrate the game to the rest of their classmates. Students will be asked to vote for their favourite games. Finally, there will be a discussion about what they have learned throughout the process. *Has anything changed in your way of thinking since the beginning? Do you think you could go into programming? Do you think it is a career for boys only?*	2 hours
Learning products	The game and the assessment of the evolution of their beliefs.	

Assessment

Initial assessment

Individual answers to the two questions posed for the discussion in the first lesson.

Formative evaluation

- Construction of an algorithm and its flowchart.
- Solutions given to unplugged games and conclusions.
- Google form answers on the FemSTEAM Mysteries game.
- The Scratch games.

Final assessment

Assessment of the evolution of their beliefs, answering the questions:

- *How did the activity help me to break the stereotypes of STEAM people?*
- *Do you want to study further STEAM subjects and/or career? Explain: what and why*
- *How can your experience with programming help others to study further STEAM subjects?*

Student feedback

Student 1 feedback:

- Which is the goal of the game?

  To learn more about important people that have improved our society and knowledge.
- What have you learned with the game?

  Who were the four room's hosts.
- What would you improve of FemSTEAM Mysteries game?

  The mobility, the camera and some bugs.
- How are you going to use this assessment/testing to improve or design your game?

  Taking notes and learning by my mistakes.

Student 2 feedback:

- Which is the goal of the game?

  To get clues about some scientific
- What have you learned with the game?

  To know how to move in a virtual world
- What would you improve of FemSTEAM Mysteries game?

  I would improve the camera movements
- How are you going to use this assessment/testing to improve or design your game?

  I will use it to help the developers to improve their FemSTEAM game

Teacher feedback

Mathematics teacher:

Such kind of activities which involve students in games help them to develop their computational thinking and learn about their own errors to surpass the difficulties that they encounter. In particular, the design-based

project is not traditionally used in the mathematics classroom. Its implementation has provided to the students the knowledge of what the E of STEAM means and how mathematics is useful for a transdisciplinary view of STEAM.

Annexes

Annex I: Unplugged games (Bell, T., Witten, I., & Fellows, M. (2015). CS Unplugged: An enrichment and extension programme for primary-aged students.)

- **Activity 1 Colour by numbers. Image representation (Representing information)**

Discussion Questions

1. In what situations would computers need to store pictures? (A drawing program, a game with graphics, or a multi-media system.)
2. How can computers store pictures when they can only use numbers?

Computer screens are divided up into a grid of small dots called pixels (picture elements).

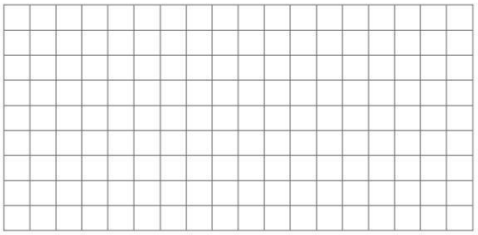
In a black and white picture, each pixel is either black or white.

The first number always relates to the number of white pixels. If the first pixel is black the line will begin with a zero.

There is usually a limit to the length of a run of pixels because the length is being represented as a binary number. How would you represent a run of twelve black pixels if you could only use numbers up to seven? (A good way is to code a run of seven black pixels, followed by a run of zero white, then a run of five black.)

Worksheet Activity: Kid Fax

The first picture is the easiest and the last one is the most complex. It is easy to make mistakes and therefore a good idea to use a pencil to colour with and have a rubber handy!



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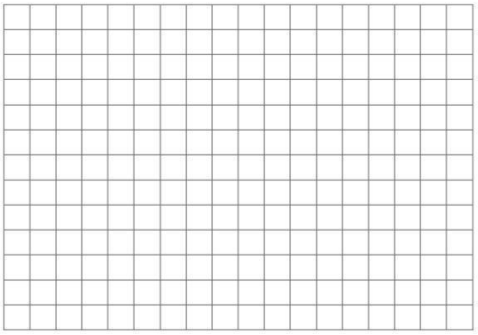
4, 9, 2, 1
4, 9, 2, 1
4, 11
4, 9
4, 9
5, 7
0, 17
1, 15



6, 5, 2, 3
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3, 1, 9, 1, 2, 1
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2, 1, 11, 1
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2, 1, 9, 1, 1, 1
2, 1, 8, 1, 2, 1
2, 1, 7, 1, 3, 1
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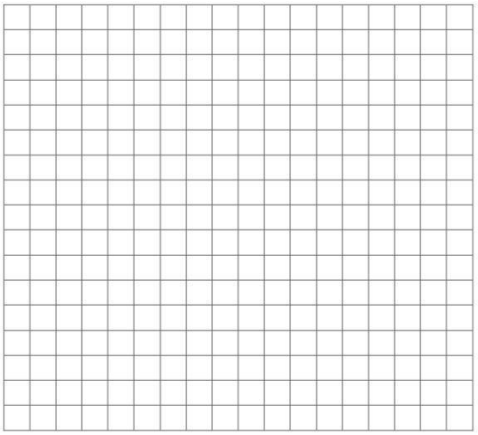
1, 3, 2, 5



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6, 6
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3, 1, 10, 1
2, 1, 12, 1
2, 1, 3, 1, 4, 1, 3, 1
1, 2, 12, 2
0, 1, 16, 1
0, 1, 6, 1, 2, 1, 6, 1
0, 1, 7, 2, 7, 1
1, 1, 14, 1
2, 1, 12, 1
2, 1, 5, 2, 5, 1
3, 1, 10, 1
4, 2, 6, 2
6, 6

- **Activity 2: Beat the clock. Sorting networks (Algorithms)**

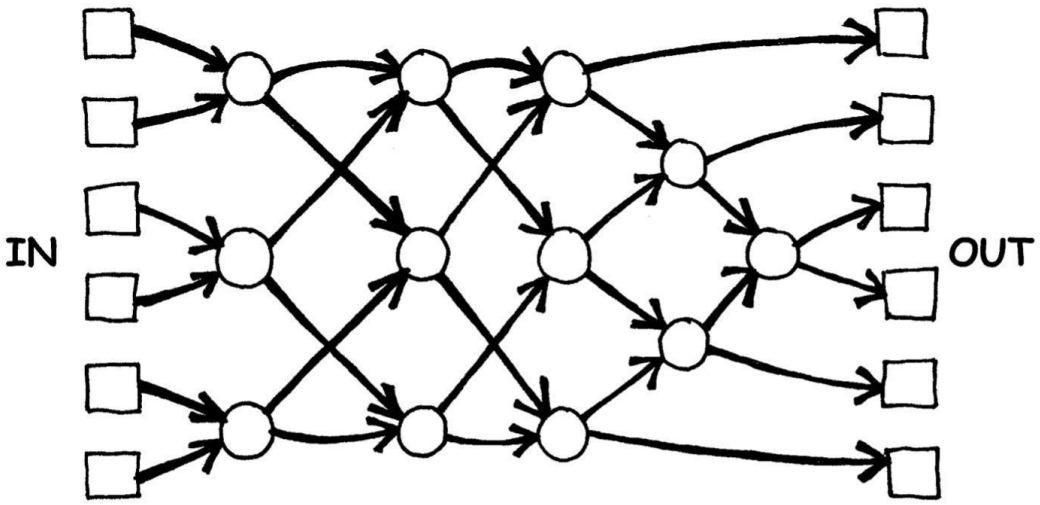
This activity will show you how computers sort random numbers into order using a thing called a sorting network.

Summary

Even though computers are fast, there is a limit to how quickly they can solve problems. One way to speed things up is to use several computers to solve different parts of a problem. In this activity we use sorting networks which do several sorting comparisons at the same time.

1. Organise yourselves into groups of six. Only one team uses the network at a time.
2. Each team member takes a numbered card.
3. Each member stands in a square on the left hand (IN) side of the court. Your numbers should be in jumbled order.
4. You move along the lines marked, and when you reach a circle you must wait for someone else to arrive.
5. When another team member arrives in your circle compare your cards. The person with the smaller number takes the exit to their left. If you have the higher number on your card take the right exit.
6. Are you in the right order when you get to the other end of the court?

If a team makes an error the students must start again.



- **Activity 3: The muddy city. Minimal spanning tree problem. (Algorithms)**

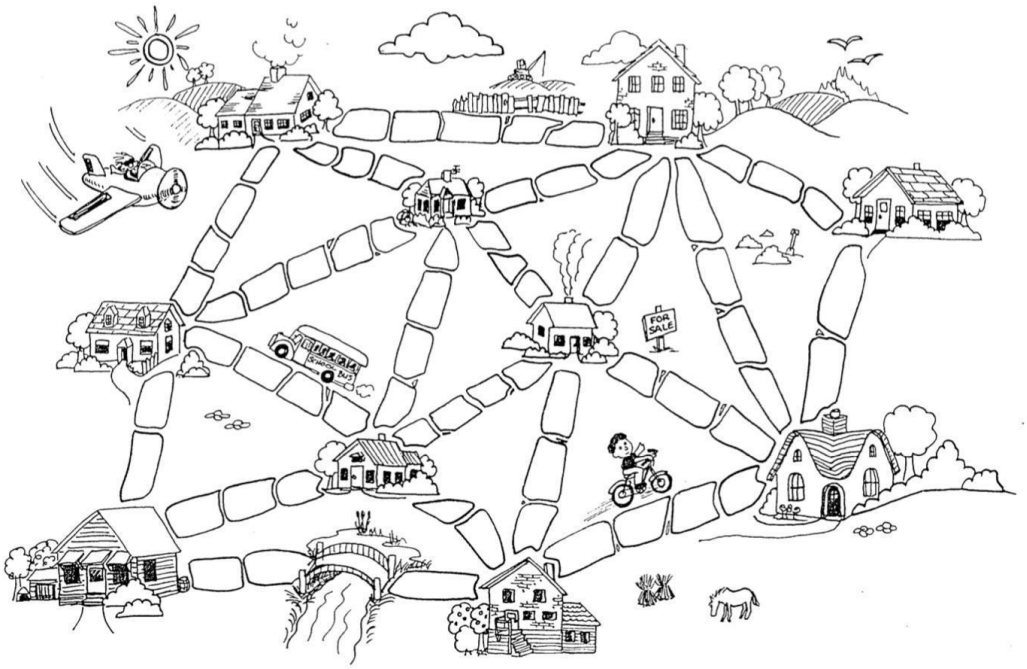
This activity will show you how computers are used to find the best solutions for real-life problems such as how to link power lines between houses.

Once upon a time there was a city that had no roads. Getting around the city was particularly difficult after rainstorms because the ground became very muddy—cars got stuck in the mud and people got their boots dirty. The mayor of the city decided that some of the streets must be paved, but didn't want to spend more money than necessary because the city also wanted to build a swimming pool. The mayor therefore specified two conditions:

1. Enough streets must be paved so that it is possible for everyone to travel from their house to anyone else's house only along paved roads, and
2. The paving should cost as little as possible.

Here is the layout of the city. The number of paving stones between each house represents the cost of paving that route. Find the best route that connects all the houses, but uses as few counters (paving stones) as possible.

What strategies did you use to solve the problem?



- **Activity 4: Conversation with computers. The Turing test (Interacting with computers)**

This activity takes the form of a game in which the students must try to distinguish between a human and a computer by asking questions and analysing the answers. The game is played as follows.

There are four actors: we will call them Gina, George, Herb and Connie (the first letter of the names will help you remember their roles). The teacher coordinates proceedings. The rest of the class forms the audience. Gina and George are go-betweens, Herb and Connie will be answering questions. Herb will give a human's answers, while Connie is going to pretend to be a computer. The class's goal is to find out which of the two is pretending to be a computer and which is human. Gina and George are there to ensure fair play: they relay questions to Herb and Connie but don't let anyone else know which is which. Herb and Connie are in separate rooms from each other and from the audience.

What happens is this. Gina takes a question from the class to Herb, and George takes the same question to Connie (although the class doesn't know who is taking messages to whom). Gina and George return with the answers. The reason for having go-betweens is to ensure that the audience doesn't see how Herb and Connie answer the questions.

Gina and George should have pencil and paper, because some of the answers will be hard to remember.

1. Before playing the game, get the students' opinions on whether computers are intelligent, or if the students think that they might be one day. Ask for ideas on how you would decide whether a computer was intelligent.

2. Introduce the students to the test for intelligence in which you try to tell the difference between a human and a computer by asking questions. The computer passes the test if the class can't tell the difference reliably. Explain that Gina and George will communicate their questions to two people, one of whom will give their own (human) answers, while the other will give answers that a computer might give. Their job is to work out who is giving the computer's answers.

3. Show them the list of possible questions in the Turing Test Questions sheet. This can either be copied and handed out, or placed on a projector. Have them choose which question they would like to ask first. Once a question has been chosen, get them to explain why they think it will be a good question to distinguish the computer from the human. This reasoning is the most important part of the exercise, because it will force the students to think about what an intelligent person could answer that a computer could not.

Gina and George then relay the question, and return with an answer. The class should then discuss which answer is likely to be from a computer. Repeat this for a few questions, preferably until the class is sure that they have discovered who is the computer.

Choose questions from this list to ask the hidden human and "computer".

1. What is the name of Bart Simpson's baby sister?

I can't remember.

2. What do you think of Roald Dahl?

He writes funny books.

3. Are you a computer?

Are you a computer?

4. What is the next number in the sequence 3, 6, 9, 12, 15?

18.

5. What do you think of nuclear weapons?

Nuclear weapons are very dangerous and should not be used.

6. What is 2 × 78?

166 (This is deliberately incorrect!)

7. What is the square root of two?

1.41421356237309504878

8. Add 34957 to 70764.

Wait for about 20 seconds before giving the answer

...105621.

9. Do you like school?

Yes, I like school.

10. Do you like dancing?

Yes, I like dancing.

11. What day is it today?

Give the correct day of the week.

12. What time is it?

Give the correct time.

13. How many days are there in February in a leap year?

2000 and 2004 are leap years. (This is deliberately incorrect!)

14. How many days are there in a week?

Seven.

15. For which country is the flag a red circle on a white background?

I don't know.

16. Do you like to read books?

Yes, I like to read books.

17. What food do you like to eat?

I'm not hungry, thanks.

- **Activity 5: The Peruvian flip coin. Cryptographic protocols (Cryptography)**

The rules of and-gates and or-gates are simple. Each “gate” has two inputs and one output. Each of the inputs can be either a 0 or a 1, which can be interpreted as false and true, respectively. The output of an and-gate is one (true) only if both inputs are one (true), and zero (false) otherwise.

The circuit on the worksheet has six inputs and six outputs. Alicia selects a random input to the circuit, consisting of six binary digits (zeros or ones), which she keeps secret. She puts the six digits through the circuit and sends Benito the six bits of output. Once Benito has the output, he must try to guess whether Alicia’s input has an even or an odd number of ones—in other words, she must guess the parity of Alicia’s input.

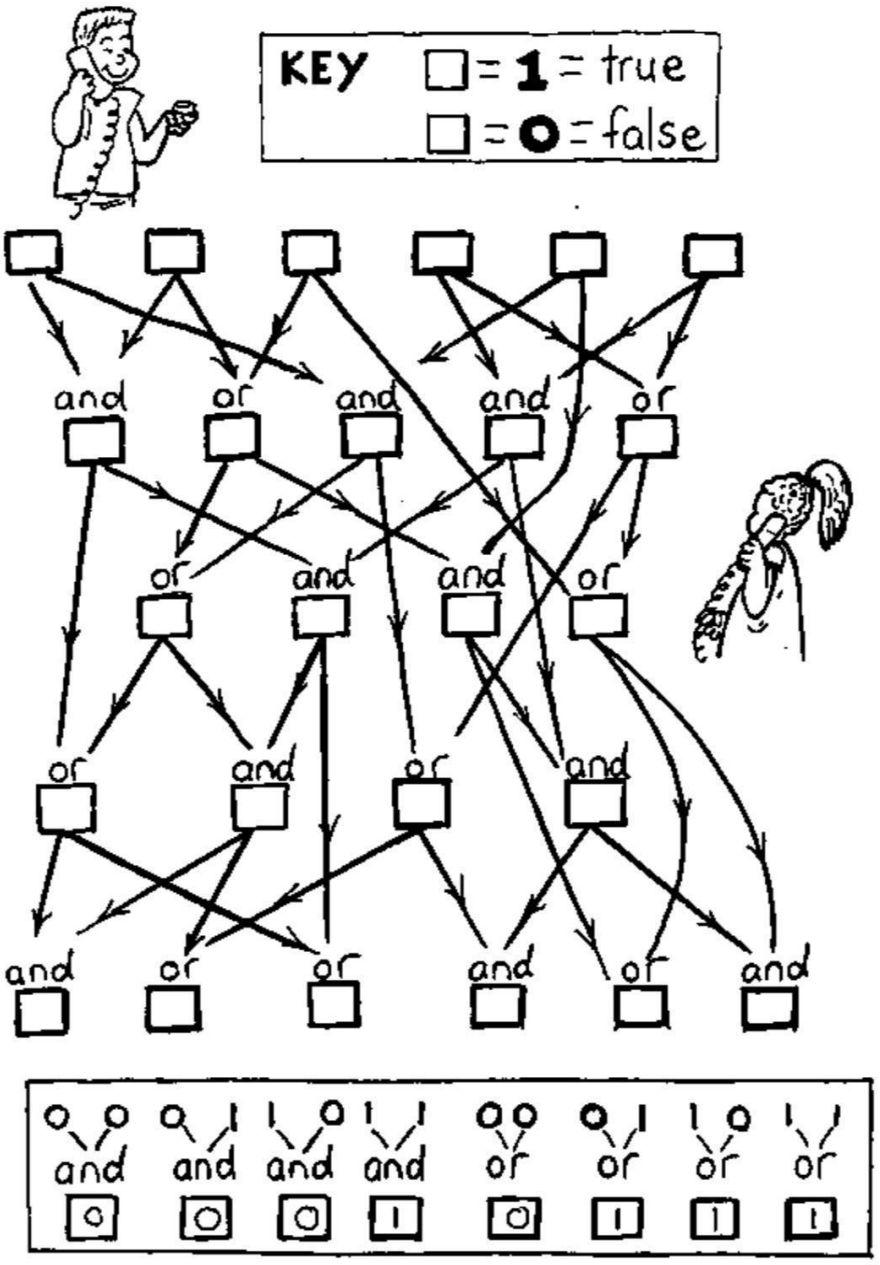
1. Divide the students into small groups, give each group the circuit and some counters, and explain the story. Establish a convention for the counter colours—red is 0, blue is 1, or some such—and have the students mark it on the legend at the top of the sheet to help them remember.

2. Show the students how to place counters on the inputs to show the digits that Alicia chooses. Then explain the rules of and-gates and or-gates, which are summarised at the bottom of the sheet (consider getting the students to colour these in).

3. Show how to work through the circuit, placing counters at the nodes, to derive the corresponding output. This must be done accurately and takes some care.

4. Now each group should elect an Alicia and a Benito. The group can split in half and each half side with Alicia or Benito respectively. Alicia should choose a random input for the circuit, calculate the output, and tell it to Benito. Benito guesses the parity of the input (whether it has an odd or even number of ones in it). It should become evident during this process that Benito’s guess is essentially random. Alicia then tells everyone what the input was, and Benito wins if she guessed the correct parity.

Worksheet Activity: The Peruvian Coin Flip



Choose some inputs for this circuit and work out what the outputs are.