Queen Mary
University of London

The Teleporting Robot

Age group: 7 – adult

Abilities assumed: Nothing

Time: 15 minutes upwards
depending on how long you want to let the class puzzle

Size of group: 1 upwards

Focus

Computational Thinking: understanding people
Human-computer interaction
Interaction design and human error

Syllabus Links

This activity can be used as a general introduction to human computer interaction (HCI) from KS2 upwards and in particular why so many gadgets are harder to use than need be. It also introduces the computational thinking ideas of translating problems and especially of understanding people.

Summary

You introduce a simple jigsaw with a picture of robots. With the class you count them – there are 17. You shuffle the six pieces of the jigsaw, then put them back together. You and the class count the robots again. It's the same jigsaw as before but only 16 robots remain. Number 17 has vanished leaving no trace! This shows how easily the human brain is confused. Some things are so complicated we can't see what is going on even when it happens in plain view. When we design human-computer interfaces, we need to keep things simple if people aren't to make mistakes using them.

Technical Terms

Computational thinking: understanding people, interaction design, human-computer interaction.

Materials

Large teleporting robot puzzle for demonstration
- laminated for durability

One teleporting robot puzzle per class member
Scissors for each class member
- if they are going to cut their own version out

What to do

The Grab:
Explain you have a magical jigsaw that contains some robots that are intelligent. The trouble is once they become intelligent they develop a sense of humour too, and one of them is playing tricks on you by disappearing and reappearing. You want the class to help work out which one it is and where they are going!

The set up:
Take the large demonstration version of the jigsaw and put the six pieces together so that there is a grey light sabre-wielding robot in the top left corner. When putting the jigsaw together green monsters go on the top row and look for the robot with the pink skirt split down the middle for the bottom row pieces.

The activity:
Have the class count the robots with you out loud starting from the bottom left corner and working across and back. There are 17 (plus a robot dog and some green monsters). Make sure everyone agrees there really are 17. Now shuffle the six pieces of the jigsaw and put them back together. This time put the top two rows back swapped left to right. There will no longer be a grey robot in the very top left corner if you have put the pieces back correctly (so start with that piece). Have the class count the robots again with you pointing to them as you count. It's the same jigsaw as before but only 16 robots remain. The 17th has vanished, leaving no trace! Which one is it and where has he gone? Has he teleported away? Has he been eaten by a green monster or is he just hiding behind another robot? How can it happen with a physical jigsaw!

Shuffle the pieces and put them back to show there really were 17. Do this a few times and see if anyone has ideas as to what is going on. Someone may notice that the pieces have been put back together differently. When they do, own up and now just clearly swap those pieces around. Ask how can that make a whole robot disappear – it doesn't explain anything. There are still the same number of robot heads and robot legs aren't there? It's the same pieces after all. They are just good recycling robots who pass their parts on when no longer needed!

Now give everyone their own copy and let them puzzle it out for a while. Often some will notice that the one on the end loses and gains the top of his head. Agree this is something to do with it, but how does someone having a close shave hair cut disappear. Others may pick on a specific robot who disappears. Get them to put their finger on each half and follow them as the pieces are moved. They will see both parts are still there after the move. You can suggest they count the number of heads or bodies (it won't help much though). Something that may help is to notice the top 4 robots are all there in both versions (just in different places). You can throw away the top row and it makes no difference, but the problem is now simpler. That is an important computational thinking skill: simplify the problem. It is very important when debugging programs, for example.

Eventually explain the secret, but only after everyone has agreed to abide by the magician's code and promised not to give it away.

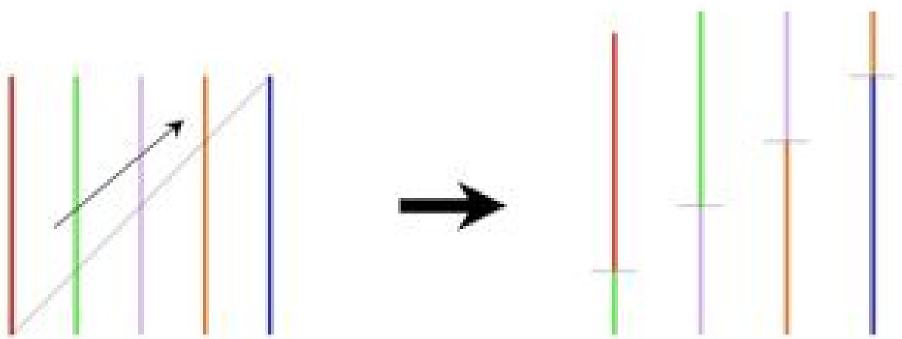
The Explanation
The puzzle works through a combination of geometry and the limitations of our brains. It shows how easily the human brain is confused. It is designed to be

complicated in a way that people cannot see what is happening, even when they know exactly what is going on.

It shows that some things are so complicated we can't see what is happening even when it is right before us. The same applies to gadgets. We find them difficult to use not because we are stupid but because they are not well designed. When we design human-computer interfaces, we need to keep things simple if people aren't to make mistakes using them. Simple elegant designs can often be far easier to use than complicated ones. TV remote controls are a good example of something made too complicated to be easy to use for anything but very simple things (and even then, get them in an odd mode and even simple things can become impossible). For a TV remote it is just irritating (though if it means you miss the start of Dr Who or Sherlock because you failed to get it in the right AV mode and then to the right channel in time that can be pretty irritating!). On the other hand, if instead we are talking about a Doctor in Accident and Emergency who has hooked you up to a life-saving machine and is trying to set it going … it matters an awful lot that they aren't struggling to get it in the right mode because it is badly designed.

So, back to the puzzle! What is going on? Well it's not about a single robot. All the robots on the bottom row contribute. They all swap pieces in a way that means they all get a little taller. The chain of swaps starts with that one that gains a top of a head from nothing. It ends with red and yellow one near the middle where the whole robot moves, as it is all above the line. As you move along the chain the amount they swap with the next one gets larger until eventually a whole body can be moved leaving nothing behind. It isn't one robot that disappears, it is that they all squash up but in a way that is impossible to see even when you know.

It is easier to see if we simplify things – applying that computational thinking trick again. Let's draw the puzzle with the robots simplified out (see the diagram below – demonstrate it using the large A3 version).



We have replaced the robots with lines representing their height. We have also put the robots/lines that swap pieces next to one another in a line. Cut along the diagonal line. Now, after counting the lines, just slide the two pieces up the diagonal and make the lines match again, just as we moved the robots to a new matching position. Count the lines and one has disappeared in exactly the same way. At one end is a line that has no part below the diagonal, at the other is a line that has no part above the diagonal. Each line in between has lost a little piece of line, but has then gained a larger piece and so gained in height. The one at the end has slid on to its neighbour, leaving nothing behind. That is exactly what the yellow and red robot has done, jumping on to the legs of another – leaving in its case a balloon behind! Bits of all the robots have been recycled into others to create a series of new, larger robots. Each loses a small bit (a part of a head say) and gains a bigger new version (a bigger head bit from someone else).

The jigsaw design is more complicated than the lines. That makes the difference. Even though logically it is exactly the same thing happening, with the lines it is quite easy to see what is happening. With the robots it is really difficult – our brains can't process it all. The presentation makes the difference.

While a magician should be trying to design a system like the robot version of the puzzle that forces people to struggle, a software engineer should be trying to design a system like the lines that is easy to follow. Unfortunately many software engineers do not think about people and unwittingly create systems too much like the magic! An important interaction design principle is to keep things simple – aim to design clear, uncluttered interfaces. The reason many everyday gadgets are so hard to use is because the emphasis has been on adding more features (many that will never be used), each one making the interface more complex, rather than focussing on making the core task easy to achieve well. Successful computational thinking has to take human limitations into account.

Variations and Extensions

Microwave Racing
Combine this activity with the microwave racing video activity for a way to demonstrate the link to interaction design. People have been designing microwaves for years. They ought to have got it right by now. Despite that many are far harder to use than necessary. Illustrate this by showing the video or even by racing them yourself using different designs to do the simple task of cooking popcorn.

Further Reading

Computing without computers

A free booklet by Paul Curzon on programming, data structures and algorithms explained using links to everyday concepts. Available from http://teachinglondoncomputing.org/resources/

The Magic of Computer Science

There are lots more magic tricks with computer science twists available from http://www.cs4fn.org/magic/ including several free magic books.

Links to other activities

Microwave Racing

Show a video of people racing microwaves. Four different microwave designs are raced to see which can be most quickly used. Demonstrates how interaction design can make a difference both in how easy a task is to complete and how easy it is to make mistake. Make things too complicated and people will struggle.

The Four Aces

Teach a trick where the Aces are stolen from a perfect hand without anyone seeing.

You do a magic trick where the audience try to keep track of the Aces. To their surprise the person who had all the Aces turns out to have nothing. You the magician have the perfect hand. How do you steal the Aces with no one noticing? Magicians design systems so everyone makes mistakes, computer scientists have to design them so no one does. This is a memorable way to show that computing is about more than just technology. It is about understanding people too.

The Invisible Palming Trick

Teach a trick where the magician invisibly moves a card between 2 piles.

This is a fun way to introduce the idea of an algorithm, showing how algorithms are a series of steps that if followed precisely lead to something (in this case magical) being guaranteed to happen – even if the person (or computer) following the algorithm doesn't know what they are doing.

The Australian Magician's Dream

Do a magic trick where you predict a card chosen that even the person choosing couldn't have known. Challenge the audience to work out how it is done, teach them how to do the trick and then use it to explain algorithms, searching, and logical reasoning.

Live demonstration of this activity

Teaching London Computing give live sessions for teachers demonstrating this and our other activities. See http://teachinglondoncomputing.org/ for details. Videos of some activities are also available or in preparation.

Department for Education

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COMPUTING AT SCHOOL
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chi+med
making medical devices safer

EPSRC
Engineering and Physical Sciences Research Council

This activity sheet was created in collaboration with CHI+MED, an EPSRC funded research project involving University College London, Queen Mary University of London, Swansea University and City University on the interaction design of safer medical devices: http://www.chi-med.ac.uk/

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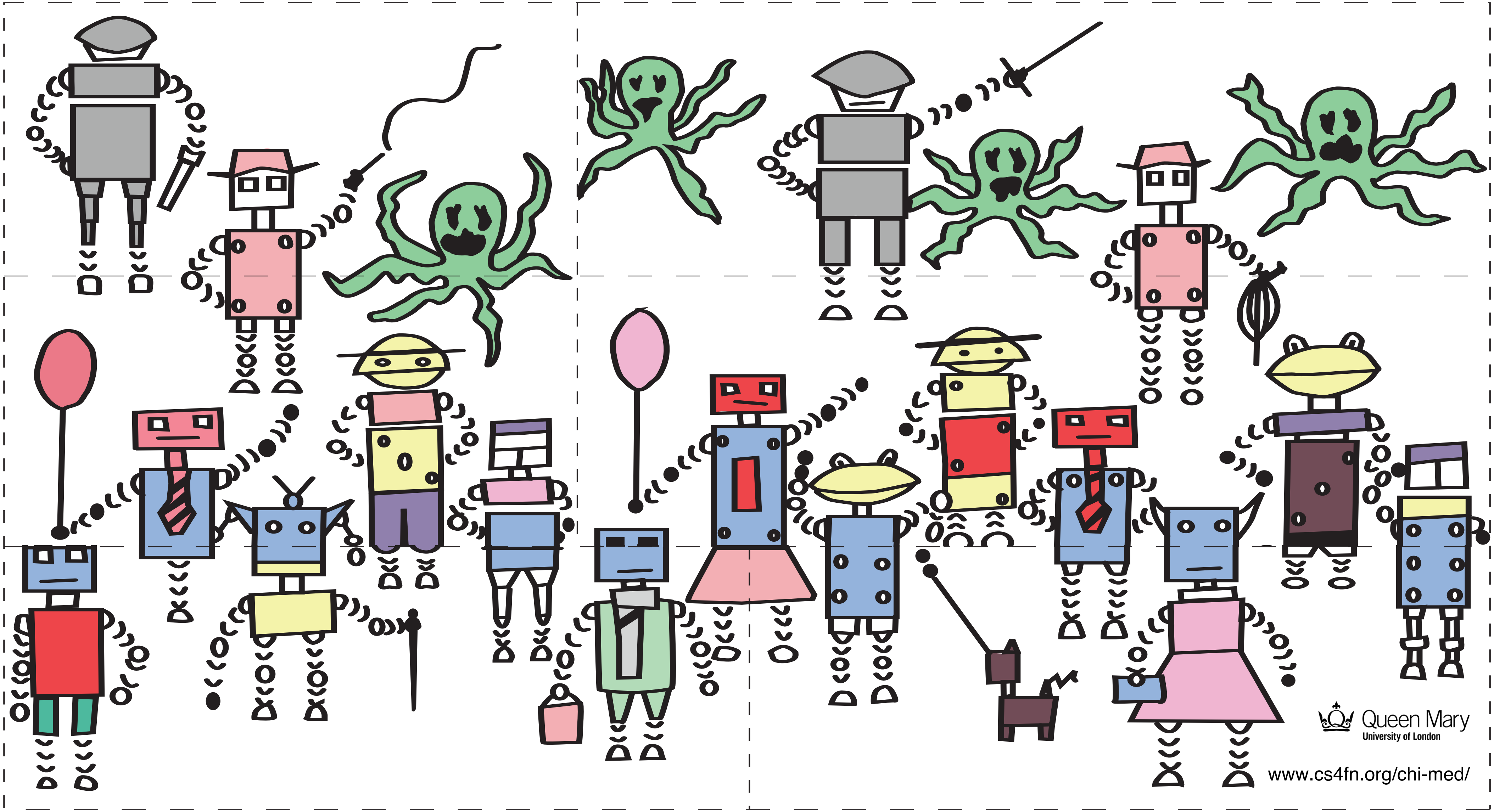

1. Punch out the six pieces of the jigsaw. **2.** Arrange them as you see here, with the short pieces on the left and the long pieces on the right, and count the robots. **3.** Now switch the top and middle sections on the left with the top and middle from the right. **4.** Count the robots again.

What's going on? Go to **www.cs4fn.org/magic/** for the answer.

Queen Mary
University of London

The Teleporting Robot Simplified