

## Activity 1

# The Intelligent Piece of Paper

**Age group successfully used with:**

8 – adult

**Abilities assumed:**

answering general questions,  
knowledge of game of noughts and crosses / Tic-tac-toe

**Time:**

around 15 minutes,  
though can be used to start a longer workshop activity

**Size of group:**

anything from 2 to hundreds

### Focus

What is a program?

What is intelligence and could a computer ever be intelligent?

### Summary

Hold a competition between an artificial intelligence: a “highly intelligent piece of paper” and a human. In this ongoing challenge between the best of humanity and the best of paper-kind the paper has an unbeaten record. It is yet to lose a game of noughts and crosses.

### Aims

This activity aims to introduce the topic of what a computer program is and how everything computers do simply involves following instructions written by (creative) computer programmers.

It also aims to start a discussion about what intelligence is and whether something that just blindly follows rules can be considered intelligent.

### Technical Terms

Computer program, programming language, artificial intelligence, programmer, peripherals.

### Materials

A whiteboard or flipchart to write on so all can see.

2 flip chart / whiteboard pens

A copy of the intelligent piece of paper (possibly laminated)

A musical greeting card that plays some appropriately horrible song. Choose one that is recognizable by the age group. (optional)

## What to do

**The Grab:** Announce that the piece of paper you are holding is more intelligent than anyone in the room (even the highly intelligent teachers there). Wax lyrical about how intelligent it is without saying why. Wave it around keeping the written side hidden from the audience.

**The Set-up:** Ask the audience if they believe you and have a show of hands: first of those who believe it is intelligent and then those who “believe I am talking total garbage and no way just a piece of paper could be intelligent”.

Usually most will go for the garbage option. Congratulate them on their wisdom (both for believing such a wise person as you and especially those that don’t – after all no good scientist believes claims of random people making great pronouncements, however great they are, without some evidence.

Ask them to bear with you for a while – perhaps it is intelligent, perhaps not, but ask for suggestions of what it might be about the paper that could be the basis of such an outrageous claim.

You may get suggestions such as it is something special about the ink, or that it is laminated. With suggestions like the former, praise them for an interesting idea but ask how that exactly might make it intelligent? Ask if the rest of the audience think it would be enough. If the latter, explain that the plastic covering is not the special thing. It is just there to protect the piece of paper as it does not like you fingering it all the time.

Another common suggestion is that there is a computer embedded in the paper. This is an opportunity to bring out a musical greeting card that plays some irritating music (and is intelligent enough to know to do it on your birthday) and explain it works via an embedded chip. You may want to mention that such a chip is as complex as the embedded computer used to put Neil Armstrong on the moon. Note that you could have done it that way with your intelligent piece of paper, but you didn’t.

Another suggestion will be that it is what is written on the paper that makes it intelligent. Ask what might be written that would make paper intelligent. Great equations? Wonderful poetry? Exciting facts? Suggest examples and ask if the audience think that would give the paper intelligence. If not, then we need to look for something more. Talk about the fact that knowledge isn’t the same as intelligence – and that they surely don’t just try to memorise things for exams but try to understand which isn’t the same. Agree that writing such things on the paper wouldn’t be enough for it to be intelligent.

Point out that to convince us that it is intelligent it must be able to do something to show that intelligence. What can the paper do? Well it has never lost a game of Noughts and Crosses (and it plays regularly against humans). Remind them that the game should end in a draw if both players play perfectly. You cannot force a win. Despite that, the paper has won about half the games it has played against humans like themselves, and drawn the rest. It is a perfect intelligence. Humans aren’t!

Ask them if they believe you or do they want to see some evidence? To show the evidence you will need two volunteers.

**The activity:** Draw a noughts and crosses board on the whiteboard/flip chart. Give each volunteer a pen. Explain that to see how intelligent the paper is you will need to play a game of Noughts and Crosses. It will not be a battle between two humans but between paper-kind and humankind. The paper is ‘peripherally challenged’ – you didn’t bring it a robotic arm or camera system (computer peripherals) so it needs a servant to do its bidding. You might want to note that just because someone is paralysed doesn’t mean they aren’t more intelligent than you.

One person will therefore play for the piece of paper. Their job is to just do what they are told by the paper. They must switch off their highly intelligent brain and do exactly as they are commanded: we don’t want to know how well they play the game, just how well the paper plays. They should just read out loud the paper’s instructions (so everyone can tell it is the paper playing not them) and do as it says.

The other player is there to represent the best of humanity. It may be best not to pick someone who was really keen and appearing to think they would never lose to do this to reduce the chances of it being a drawn game (though often such volunteers still lose). Their job is to use all their intelligence to play as well as they can. As the paper is so intelligent, to make it fairer, say they can get help from the audience if they need it. Tell the audience to shout out if they think a mistake is being made or know the move to make.

Now get the person playing for the paper to read its instruction starting with it wanting to go first. Comment that it is quite clever of it to want to go first. If someone complains about it being unfair, point out that the game should just end in a draw whoever goes first. Going second isn’t a reason to lose.

The paper’s servant should then read out the first move and make the move: playing in a corner. Over to the human. There may be lots of shouts about different places to go. If the person is unsure encourage them to go where they think best of the options shouted. Continue like this, making sure the reader does read out and follow exactly the instruction and helping them understand where they are being told to go if need be. For example, “opposite corner”, means the diagonally opposite corner. This can later lead to a discussion of why special programming languages are needed: to be precise about what is to be done.

Sometimes after the second or third move people in the audience will declare the game lost. Point out humanity does often resign at this point. Remind them it is only a piece of paper though. It might just have been lucky this far so might still mess up and not see what they can see.

If the paper has forked them, then often the player will jokingly cheat, such as drawing two 0s. Point out that humanity often resorts to cheating at this point, and make them play properly, reminding them it is only paper and may still go wrong.

Either the paper will win or it will be a draw (if the human realises they need to go on the side not corners). If the latter then remind everyone that that was predicted but

that even so it was still clever of it to not let the human win. Announce that once more it has kept its unbeaten run. Say you'll accept that perhaps it's not more intelligent than the humans but it has shown itself to be their equal. If the paper wins announce that yet again the paper has shown itself more intelligent than humanity and that you have shown them the evidence asked for.

Either way ask for applause both for the volunteers as they return to their seats and the paper for its stunning performance.

**The explanation:** Point out they asked for evidence and you have given it. Ask again for a show of hands as to who now believes the paper is intelligent and who believes you are talking garbage and paper can't be intelligent. Usually everyone now is sure it isn't intelligent, despite the evidence of its abilities.

Point out that it did show intelligent behaviour so there is intelligence somewhere. Where is it? Someone will almost certainly say it is in the person that wrote the instructions. Ask if everyone agrees that that is where the intelligence is and get a show of hands. [You can then thank them from me for recognizing my great intelligence :-)]

Now explain that what is on the paper is essentially a computer program: instructions to be blindly followed. Everything they have ever seen a computer do, it was just doing by blindly following instructions in the same way. Point out that if they are saying that the paper is not intelligent because it is just following rules, then they are saying no computer could ever be intelligent either.

These instructions were written in a language so that a human can follow them. If they were to be written for a computer they would be written in a programming language: just a language a computer can understand precisely and so follow. Point out that if they think that it is the writer of the instructions who is the creative intelligent one, then they are saying that computer programmers are intelligent and creative (which is true). It is computer programmers who have written all the instructions all those computers are following.

## Variations and Extensions

If there is time you can explore what happens if the paper goes second. Get two more volunteers to try it out. The paper loses straight away and looks very silly in the way it plays. You can point out though: "my other piece of paper can play second perfectly". This can lead to a discussion of what Artificial Intelligence researchers call the "Frame Problem". A computer can seem quite clever when doing the tasks it was programmed for but can look very silly with just small changes to the task it is trying to do. When a programmer writes a program they have to ensure they have thought through all the possibilities that might arise in advance.

This can introduce a discussion of chess playing computers and Deep Blue – the computer that beat Kasparov, the best human chess player on the planet. It did so just following rules written by programmers. However, Deep Blue can play chess better than the humans that created it – Kasparov can easily beat them at chess, individually or as a group. They were still able to create a computer that was more intelligent (at playing chess) than them.

A follow up activity can be for the class in groups to try and devise their own instructions that can play noughts and crosses perfectly whether they go first or second. This can be done writing instructions on cards, using a range of fixed statements like “Go in the middle” put into IF-THEN rules. Hold a knockout tournament between each group’s set of rules. A simple to use online version of this activity is also available at: <http://www.cs4fn.org/programming/noughtscrosses/>

If someone comes up with a good set of instructions then the original piece of paper can challenge it for the “World Championship”. Against a perfect set of instructions for playing second, the game should always end in a draw if the original piece of paper goes first. What will happen if the paper has to go second though? Get the class to predict what the result will be. You can also get the paper to challenge a copy of itself. What will happen then?

This can further lead to a discussion (or activity) of how to come up with a perfect set of rules by exhaustively playing all possible games. Symmetries can be used to reduce the number of possible game positions to consider as can spotting when a position has been reached before. This was how the actual “intelligent” paper’s instructions were devised (It takes few sides of paper and lots of attention to detail to do it). It is also the basics of the way AI game playing programs can work out moves for themselves rather than the specific moves being programmed like this.

## Further Reading

### cs4fn Programming FUNDamentals

*More on what programming is all about.*

<http://www.cs4fn.org/fundamentals/programming.php>

## Links to other activities

### Where is the computer (forthcoming)

*Spot all the computers in the room including the ones being worn.*

This can be used as an introduction to the Intelligent paper activity.

### Sweets learning computers (forthcoming)

*Make a computer that teaches itself to play a game perfectly.*

A computer can be programmed to work the rules of how to play the game out for itself (so where is the intelligence then?) This activity is one way to illustrate how that can be done.

### Brain in a bag

*Make a neural network out of rope and toilet roll.*

Once the group agrees that intelligent things don’t blindly follow rules, this activity can be used to show how the brain works – and that it follows rules.

### Conversations with computers— *The Turing test* (CS Unplugged activity)

*How would you tell if a computer was intelligent?*

Having possibly dismissed the idea that something following rules is intelligent move on to explore how you would tell if a computer was intelligent or not.

I am a highly intelligent piece of paper. Let's play Noughts and Crosses.

I am X... and I go first...

**Move 1:** Go in a corner.

**Move 2:**

IF the other player did not go there  
THEN go in the opposite corner to move 1.  
ELSE go in a free corner.

**Move 3:**

IF there are 2 Xs and a space in a line  
THEN go in that space.  
ELSE IF there are 2 Os and a space in a line  
THEN go in that space.  
ELSE go in a free corner.

**Move 4:**

IF there are 2 Xs and a space in a line  
THEN go in that space.  
ELSE IF there are 2 Os and a space in a line  
THEN go in that space.  
ELSE go in a free corner.

**Move 5:** Go in the free space.