Robots Teachers' Notes - read more about Connect on the web at: *www.nms.ac.uk/connect*

Robots: From the world's first artificially intelligent robot to designing your own. You can control our robots as they spell your name, or explore an alien planet. Find out how robots are developing and what they might do for us in the future.

Table 1 Robots objects

Object	Description	Background information
Freddy the Robot	Freddy was the world's first thinking robot. She was designed to perform specific tasks in the way a young child would. She was built by researchers at the University of Edinburgh in the early 1970s.	Freddy was one of the earliest artificial intelligence (AI) systems to combine perception and action. The robot was built in the 1970s at Edinburgh University. The robot was stationary, but has a moving TV 'eye' and a pincer 'hand'. It could recognise a variety of objects -including a hammer, a cup and a ball- with about 95% accuracy and even assemble simple objects. Recognising one object took several minutes of computing time. When the parts for a wooden toy car or ship were dumped in a random heap in Freddy's workspace, the Versatile Assembly Program enabled Freddy to identify and locate the parts, then put them together using hand/eye co-ordination. A wide angle camera was used to locate the parts. Freddy's video cameras then took a digital image of the parts, which appeared as light objects on a dark background. A narrow angle camera examined each cluster of parts and any that were recognised were put in their reserved area on the workspace. The unrecognised parts were treated as "heaps". To separate parts from a heap Freddy employed one of three strategies. The first was to look for a projecting part and try to grasp it, the second was to grab at the heap and if that failed Freddy would "bulldoze" through the heap. Any parts removed from the heap and identified were placed in their reserved area on the workspace. Once all the necessary parts had been identified, the program would start the assembly using a force sensor to guide insertions. Due to limited computational power in the 1970s Freddy was slow-moving and took about 16 hours to assemble an object. Even with advances in technology and computing, getting a robot to do this kind of task is fairly complex and ambitious. In the 1970s when everything had to be designed and built including the programming system, it was a pioneering feat. Freddie's creators imagined that robots like Freddy could be used for tasks like production-line assembly work and automatic parcel handling.

Table 2 Interactives

Interactive	Description	Background information	Learning Outcomes
Alpha-bot (best for 5-11 yrs)	An interactive which lets you interact with our Alphabot! Type your name on a keyboard and watch the robot spell it out.	A **robot** is a machine or device which operates automatically or under some degree of human control. They are capable of performing a variety of human tasks, often difficult or undesirable ones. To perform these tasks they must be 'told what to do'. Robots that work under human control are given commands when they are working. Robots operating automatically are given a set of instructions "**programmed**" in advance. The Alpha-bot robot operates automatically. It has been given a set of instructions (programmed) that allows it to respond to the names being typed into the keyboard. For each letter typed the program tells the robot which building block to pick up. For example, if you type A it will always go to the first building block, if you type B it will go to the second building block, and so on until you type Z, when it will go to the last building block. After the name has been spelled out the robot must always return the building blocks to the same position. If the building blocks were mixed up with A in place of Z and you asked Alpha-bot to spell AT it would spell ZT. The arm would still go to the first position for A, but it would pick up Z instead. Unlike humans Alpha-bot can't see the letters on the building blocks and think for itself. It only knows where to find the building blocks because it has been given instructions on where they are. If the sequence of letters changes Alpha-bot must be re-programmed. Can we create a robot that thinks and acts like a human? At present, robots are designed and programmed to carry out specific tasks. Unlike humans, robots don't think for themselves but carry out the instructions we have given them. As technology becomes more advanced robotic behaviour also advances. Today robots can learn and make choices but they still rely on a human to give them their initial instructions.	Robots only do what we tell them to. Encourages visitors to think about whether robots can 'make mistakes'. How does it find the right blocks? It knows where to find each block and always returns it to the same spot. If you scrambled the blocks, it couldn't spell your name.

Interactive	Description	Background information	Learning Outcomes
Design a Robot (best for 7+ yrs)	In this computer interactive you can design a robot to carry out different tasks e.g. companion robot or bomb disposal. First decide why you need a robot. Then decide on the various components or characteristics your needs. You can then test your design.	**Robots** are devices which are used to carry out tasks either autonomously or under some degree of human control. They are usually used to conduct a multitude of tasks which humans find undesirable (e.g., too dangerous). For example, robots have been used to explore the surface of Mars, detect mines, work on factory assembly lines and even vacuum carpets. At present, robots are mostly designed for a specific purpose; they are not yet like the multi-tasking androids we see in science fiction e.g. 'Data' from 'Star Trek'. A robot on an assembly line couldn't explore the surface of Mars for example.	Robots can be useful for a number of different tasks.
Robot Explorer (best for 6-12 yrs)	In this interactive you can programme a robot to find its way across the surface of an alien planet.	**Robots** are devices which are used to carry out tasks either autonomously or under some degree of human control. They are usually used to conduct a multitude of tasks which humans find undesirable (e.g. too dangerous). One of the tasks humans use robots for is to **explore** places where we cannot go -- e.g., deep under water, or other planets. One of the challenges when designing a robot for exploration is that the terrain is unknown. A human operator has to see pictures of the landscape before they can give the robot instructions to move safely. Most exploration robots send back pictures of their environment (with an on board camera) to the operator, and the operator can then send back instructions to the robot. However, it isn't always practical to rely on this method of navigation alone. For example, images can sometimes be difficult to interpret or, in the case of Mars lander robots, the communication time delay between Earth and Mars was 10 minutes. In these situations the robot may encounter a hazard that the operator hasn't seen or been able to tell the robot to avoid in time. The robot is on its own and has to have programming which allows it to operate (semi-) autonomously. Sojourner (the first "smart" Mars lander) had a hazard avoidance system that allowed it to change direction if it calculated an obstacle was too high to climb (risking tipping). **Artificial intelligence** (AI) systems like this allow robots to complete more complex tasks without requiring every tiny detail to be anticipated and pre-programmed by an operator.	How to give instructions to a robot. That a non-AI robot needs very precise instructions which can be hard to give in an unknown environment.

Interactive	Description	Background information	Learning Outcomes
Robot Ships (best for 5+ yrs)	Robot ships is a unique projection interactive based on current research carried out at the University of York. It lets you interact with virtual robots. In this table top activity you work with virtual ocean tankers and robots. If the tankers crash into islands they leak their cargo of toxic goo into the sea. Autonomous seeker robots search the tabletop ocean, navigating around the moveable islands, in search of toxic spills. Once found, a spill is cleaned up by cleaning ships. You can help or hinder the progress of the tankers, seeker robots and cleaning ships by moving the islands around the tabletop.	Can we create a robot that thinks and acts like a human? Why do we want robots, and what are they good for? Instead of building one, extremely complicated and intelligent robot some researchers are **programming** groups of simple robots which can follow simple rules to work together and solve more complex problems. A major focus of robotics and **artificial intelligence** (AI) research over the past 15 years has been biologically-inspired **adaptive** robots. Their design and programming is inspired by real biological systems (e.g. ant colonies) which allows simple, autonomous individuals to develop strategies to get out of problems and cooperate with each other. Whilst this technology is not as mature as the better known fully-programmed robots used in car assembly, for example, these robots are much more able to adapt to unforeseen circumstances. Bio-inspired robots are truly “lifelike”, not in the sense of anthropomorphic features such as eyes, nose and ears, but by displaying similar behaviours to all types of animate creatures: • they move • they sense their environment and react to it in real time • they have clear goals • they are not fully deterministic • they take steps to protect themselves Much of the work in this field has concentrated on understanding what can be done with such robots. The robots themselves can be real or, as in the case of this interactive, simulations to allow exploration of different programming options.	Artificial intelligence (AI) can enable robots to adapt their behaviour and solve problems. Robot researchers are looking at how to make 'colonies' of small simple robots that work together. In future, the programming that has been developed for this virtual simulation could be used to control real robots on search and retrieve missions.

Interactive	Description	Background information	Learning Outcomes
Reaction Timer (best for 5-12 yrs)	This fast moving interactive challenges you to test your reaction speed and then gives feedback about how fast contemporary computers can 'think' . The results might surprise you!	How fast can **robots** think and move compared to people? Early robots were limited by computational power. Today robots are more limited by the complexity of the task. For example, computers and robots now perform many tasks faster than humans, such as calculations and processing information. When robots are built to act like humans they are slowed down by the number of instructions they must process to do the task. For example, when we see the reaction timer light we 'automatically' press the button. We don't have to think about raising our arm and pushing the button. This is something we have learned to do as a child and we now do it automatically - without consciously thinking about it. When the robot 'sees' the light it needs to follow instructions telling it how to raise its arm and press the button, which takes longer. Can we create a robot that thinks and acts like a human? Robots don't think for themselves but carry out the instructions with which we program them. As technology becomes more advanced the way robots are constructed and behave also advances. Today we have robots with 'artificial intelligence' whose programs allow them to learn and make choices. However, building robots that think and act like humans is not necessarily the way forward. Adaptive robots that move, sense their environment and react to it, including unforeseen circumstances, in real time are probably more useful.	Computer processing speeds are amazingly fast; however the amount of 'thinking' required by a humanoid robot to just move around means they actually move very slowly.

Table 3 Robots: keywords , concepts and curricular links

Interactive	Keywords and concepts	Curricular links	Renfrewshire Topics (Edinburgh)
Alpha-bot	"Can robots think like humans?" "How do robots work?" Programs Robots	**Technology:** Processes and how they are applied Level D – give examples of familiar processes that work by controlled sequences of events [ISE5-14 KUT-D3.1]. Level E – describe familiar processes that work by controlled sequences of events, including some that are automated [ISE5-14 KUT-E3.1]. Level F - Describe a range of processes and control devices, including some used in commercial production [ISE5-14 KUT-F3.1]. Level F - Demonstrate techniques and procedures used to communicate and make solutions to practical problems, including some used in commercial production [ISE5-14 KUT-F3.2]. **ICT:** Controlling and Modelling - Control hardware Level A – Explore the use and operation of simple devices [ISE5-15 CM-A6.4]. **ICT:** Controlling and Modelling - Knowledge of terms and uses Level B - Name main parts of devices used, and describe what the devices can do and simulate [ISE5-15 CM-B6.5]. Level C - Know and be able to label the main parts of a robot arm, e.g. forearm, wrist and gripper [ISE5-14 CM-C6.5].	

Interactive	Keywords and concepts	Curricular links	Renfrewshire Topics (Edinburgh)
Design a Robot	"Design & technology" "Different robots can be designed for many different tasks." "Humans can design robots to tasks humans are unable/do not want to do." Robots	**ICT:** Controlling & modelling Level E - have appreciation of the positive value that control devices bring to people/society [ISE5-14 CM-E6.5]. **Technology:** Needs and how they are met Level A – talk about some everyday needs and the things that are made to meet these [ISE5-14 KUT-A1.1]. Level C – suggest how people's needs differ. Suggest ways in which people can meet needs of other living things and the environment [ISE5-14 KUT-C1.1 & 3]. Levels D & E – explain how technological activity can affect the needs of people and the environment [ISE5-14 KUT-D1.4 & E1.4]. **Technology:** Processes and how they are applied Level E – describe familiar processes that work by controlled sequences of events, including some that are automated [ISE5-14 KUT-E3.1]. Level F – describe a range of processes and control devices, including some used in commercial production [ISE5-14 KUT-F3.1]. **Technology:** Skills in technology – preparing for tasks – developing informed attitudes	

Interactive	Keywords and concepts	Curricular links	Renfrewshire Topics (Edinburgh)
Program a Robot	Artificial intelligence (AI) "Design and Technology" Exploration "Humans can design robots to tasks humans are unable to do." Program Robot	**Earth and Space**: Earth in space Level D – give some examples of approaches taken to space exploration [ISE5-14 ES-D1.2]. **ICT:** Controlling & modelling Level B - with assistance, use suitable application software (e.g. LOGO) to control the movement of a real or virtual object (e.g. a turtle) at a basic level [ISE5-14 CM-B6.3]. Level C – use a mobile robot and control it to follow a precise path on the floor (e.g. Maze) [ISE5-14 CM-C6.4]. Level E - have appreciation of the positive value that control devices bring to people/society [ISE5-14 CM-E6.5]. **Technology:** Needs and how they are met Level C – suggest how people's needs differ. Suggest ways in which people can meet needs of other living things and the environment [ISE5-14 KUT-C1.1 & 3]. Levels D & E – explain how technological activity can affect the needs of people and the environment [ISE5-14 KUT-D1.4 & E1.4]. **Technology:** Processes and how they are applied Level E – describe familiar processes that work by controlled sequences of events, including some that are automated [ISE5-14 KUT-E3.1]. Level F – describe a range of processes and control devices, including some used in commercial production [ISE5-14 KUT-F3.1]. Skills in science & technology – preparing for tasks, planning, developing informed attitudes	**P6 – The Solar System** Give some examples of the approaches taken to space exploration.

Interactive	Keywords and concepts	Curricular links	Renfrewshire Topics (Edinburgh)
Robot ships	Adaptive Artificial intelligence (AI) "How do robots work?" Program "What can robots be used for?"	**ICT:** Controlling & modelling Level E - have appreciation of the positive value that control devices bring to people/society [ISE5-14 CM-E6.5]. **Technology:** Needs and how they are met Level A – talk about some everyday needs and the things that are made to meet these[ISE5-14 KUT-A1.1]. Level C – suggest how people's needs differ. Suggest ways in which people can meet needs of other living things and the environment [ISE5-14 KUT-C1.1 / 1.3] Levels D & E – explain how technological activity can affect the needs of people and the environment [ISE5-14 KUT-D1.4 / E1.4]. Skills in technology – preparing for tasks Skills in science – investigation, forming theories, developing informed attitudes	
Reaction Timer	How do robots work Robots Programes Can robots think like humans?	**ICT:** Developing informed attitudes - Know why ICT is used Level C - Have appreciation of the positive value computers/ICT bring to people/society in terms of: communication, speed, accuracy, safety and quantity/quality [ISE5-14 DIA-C7.2].	