

## Lesson 15 – Computer Models and Simulations 1

**By the end of the lesson you will know about:**

- The advantages and disadvantages of simulation
- Different types of computer models and simulations

Modelling and simulations are two closely related computer applications that play a major role in the science and engineering fields. Scientists and engineers used models to help them understand processes and determine optimal solutions.

Models are representations of a system of interest and are used to investigate possible improvements in the real system or to enable the analyst to predict the effect of changes to a system. A model is a simpler version of the system it represents. For example, a computer model of an aircraft which consists of 3D visualisations, enables the user to rotate and zoom in / out allowing them to get a closer look at the interior of the aircraft.

Simulation is the mimicking of a real system on a computer application. It is the process of using a model to study the behaviour and performance of an actual system. The purpose of using a simulator is to study the characteristics of a real-life system by manipulating variables that cannot be controlled in a real system. For example, a flight simulator replicates the equations that govern how an aircraft flies and how an aircraft reacts to external factors such as air density, turbulence, wind shear, etc.

When compared to real experiments, simulations have the following advantages:

- Real experiments may turn out to be very expensive, especially if something goes wrong.
- Simulations are used to estimate the effect of extreme conditions. To do this in real life is dangerous or illegal. Critical scenarios can be investigated through simulation with no risk.
- Simulations allow users to explore “what-if” questions and scenarios without having to experiment on the real system itself.
- Simulations are repeatable with the exact same parameters, while it is difficult and sometimes impossible to repeat real-world experiments.
- By using simulators, time can be compressed or expanded to allow for a speed-up or slow-down of the phenomenon - it is possible to simulate weeks, months or years in seconds of computer time.

Like any other tool, simulations have limitations:

- Simulations can become costly and time consuming. For example, very powerful computers and skilful people are required for simulation development.
- Simulation models are not easy to develop.
- Sometimes it is difficult to interpret the simulation results.

## Activity 1

Computer models and simulations have many different uses, including:

- Education and training
- Planning, forecasting and decision making
- Medicine and scientific experiments
- Product design and development
- Entertainment

The main advantages of a simulated environment are they are low cost and low risk. For example, dangerous scenarios encountered when flying a plane can be investigated without any risk, using a simulator.

Variables can be changed and different solutions can be explored resulting in a range of possible outcomes.

The technology to support simulated environments ranges from simple diagrams, where the user may drag and drop annotations, to fully interactive virtual reality devices (headsets, data gloves) which immerse the user in the experience.



Simulated environments can be used for both entertainment and training.

### Take A Look!

Your teacher will show you a game environment.

This simulation tests the user's understanding of physics and logic.

Decide which tools to use and where to place the dynamite in order to safely blow up the buildings.

Demolition is usually a dangerous process. This simulation tests the user's understanding of structures and weak points without any exposure to risk.



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## Activity 2

### Show Me How

Your teacher will give you a link to another simulation program.

Working in a group, test and review the simulation using the form below.

Name of simulation program:

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URL:

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**Purpose of simulation or model (what does it do)?**

**What age group is the simulation aimed at?**

**How clear are the instructions?**

**Does the simulation fulfil the purpose? What are the positive attributes?**

**What don't you rate about this simulation (i.e. what you don't like about it)?**

**Is this game educational (does it teach you anything)? Yes/No?**

**What rating would you give it?:**

**Poor   1   2   3   4   5   6   7   8   9   10   Excellent**

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## Guidance notes for teachers

### Activity 1

Discuss how IT simulations are used in the real world and compile a list of suggestions from the class. Suitable answers may include: learning to fly, patient simulators in a medical environment, simulating high risk environments such as space, demolition etc.

Share the following link (or a suitable alternative of your choice) with the students and give them sufficient time to explore the game environment. Note the game is Flash-based and must be played on a supported browser.

<http://www.learn4good.com/games/building-construction/dynamitegame-explosivedemolition.htm>

This activity is clearly intended to be a game, but you can use it to prompt a discussion as to how similar environments are used in the fields of science and engineering.

### Activity 2

Organise the class into small groups (3 – 4 suggested) and allocate one of the following suggested simulation programs (or suitable alternatives of your choice) to each group.

#### Arm surgery

- <http://www.minigamers.com/games/operate-now-arm-surgery-2~14385/>

#### Air traffic control

- <http://www.learn4good.com/games/simulation/airtraffic-controller-airportmanagement.htm>

#### Bridge building

- [https://www.learn4good.com/kids-games/simulation/build\\_bridge\\_across\\_canyon.htm](https://www.learn4good.com/kids-games/simulation/build_bridge_across_canyon.htm)

#### Flight

- <http://www.learn4good.com/games/flying/freegame.htm>
- <http://www.learn4good.com/games/flying/airplanesimulation.htm>

#### Ear surgery

- <https://poki.com/en/g/funny-ear-surgery>

#### Driving

- <http://www.learn4good.com/games/simulation/driverseducation.htm>
- <https://www.crazygames.com/game/city-car-driving-simulator>

#### Fire fighting

- <http://www.learn4good.com/games/online/firefighter-truck.htm>

#### Air transport

- <http://www.learn4good.com/games/simulation/helicoptergame.htm>

### **Airport terminal**

- <https://www.learn4good.com/games/business/management-simulation.htm>

### **Drone pick up services**

- <https://www.learn4good.com/games/simulation/uav-drone-flying.htm>

### **Deep sea diver**

- <https://www.learn4good.com/kids-games/adventure/submarinegame.htm>

### **Bed and breakfast**

- <https://www.learn4good.com/games/online/hotel.htm>

Students explore the simulation and evaluate the activity using the form provided. It may be useful to work through the form as a whole class prior to students starting, ensuring students fully understand what each question is asking.

You may also choose to ask students to consider how well the user interface supports the activity?

Allow sufficient time at the end of the lesson for each group to share their findings with the rest of the class.

### **Resources**

- Computers with Internet access

### **Abbreviations**

- VR Virtual Reality

## Lesson 16 – Computer Models and Simulations 2

**By the end of the lesson you will know about:**

- Different types of computer models and simulations
- Closed system and open system

### Computer Simulation Areas of Applications

Computer simulations have become a useful tool for many industries. Below are some application areas of computer simulations.

#### Manufacturing

Manufacturing simulations use computer modelling to understand and improve the manufacturing processes such as production, assembly, and inventory. Manufacturing simulations can be used to perform the following analysis:

- Parts produced by unit of time
- Amount of time parts spend in the system
- Amount of time parts spend in a queue
- The utilisation percentage of machine and workers

Mass customisation has placed great pressure on manufacturers to develop and install manufacturing systems that can deliver high volumes of high-quality goods at low cost to meet local needs. This led to huge investments in manufacturing plants and associated control systems. It is vital to ensure that such systems operate as intended, and hence, manufacturing simulation are used in designing and implementing these manufacturing plants and systems. Examples of manufacturing simulations include food manufacturing, semi-conductor wafer fabrication, beverages, automobile manufacturing, aerospace, shipbuilding and materials handling.

Simulations allow the comparison of alternative designs and control policies on the model before starting to build the physical plant. Simulations help to reduce the cost and risk of large-scale errors. Simulations are used in existing plants to find better ways to operate, and these studies may be one-off exercises or may be part of periodic checks on the running of the system.

#### Medical and Health care

Hospitals and healthcare systems are complex with a huge range of variables that impact the performance of patient care. By using simulation insight to make stronger decisions, healthcare organisations can reduce the risks to patients, staff and financial investment. For example, simulations have been used to study the distribution of antibiotics and vaccines to dispensing centres in the event of a terrorist attack, in planning to move goods and equipment around a large new hospital in an effective and efficient way, in the planning of effective emergency departments and to assess the effect of different treatment programmes.

Simulations are also widely used in the medical field for training practitioners in a multitude of skills and environments. Medical simulation training allows the acquisition of clinical skills through hands-on practice rather than an apprentice style of learning. With the advanced technology, simulation tools serve as an alternative to real patients, which allows practitioners to perform procedural mistakes and learn from the mistakes without the fear of harming the patient.



## **Transport Industry**

Simulation is widely used by transportation sectors. Transport planning and fleet management has many complexities from scheduling and maintenance to, risk management and human resource. Simulations can effectively manage transport resource planning, maximise transportation loads and calculate the probability of traffic cost overruns.

In aviation, simulations have been used to plan large passenger terminals including systems for moving baggage, to ensure that passengers can get to departure gates in time and to ensure that air space is used efficiently and safely by air traffic controllers.

The shipping sector has been a long-term user of computer simulations. In fact, one of the computer simulation programming languages, CSL, was first developed by Esso, the predecessor of Exxon, to support simulations of the movement of crude and refined oil around the world.

The road transport sector uses computer simulations both to plan and investigate road traffic systems in general. Traffic simulations are now a standard tool for traffic planners because they allow for the testing of different road configurations and management controls to be refined before their physical implementation.

## **Military and Defence**

Applications of simulation in the defence sector range from studies of logistics operations through to battle simulations, which investigate possible strategies and tactics to be used in defence or attack. The aim here is obvious: no army wishes to be defeated and the chance to develop tactics beforehand and to prepare counteractions is important.

## **Training and Education Sectors**

Modelling and simulation is breaking out from traditional uses and becoming an increasingly important tool for education and training. Simulation training provides a realistic, immersive experience in the context of the learner's job role. Below are some reasons why simulations are used in training and education:

- Applicable to learners of all levels and ages
- Helps learners discover complex relationships that would otherwise involve expansive equipment or dangerous experiments.
- Allows for math, science, and engineering skills to be taught in an applied and integrated manner.
- Cost effective and reduces risks to humans.

Aviation simulators are widely used for pilot training. The main purpose of an aviation simulator is to help the pilot to achieve, test and maintain proficiency in handling aeroplane operation without involving any risk to lives. However, the simulator is not able to replicate the mental conditions or stress level in a pilot when flying an actual aircraft.

In the past, surgeons practiced on animals. But today, simulators are transforming how surgeons learn. Surgery simulators can mimic the organs and skin of human bodies, complete with bleeding, breathing, and blinking. Surgery simulation is an excellent way to learn in a low-risk environment.

Mathematician and economists can use simulations to study probabilities and statistics in a theoretical event.



## Activity 1

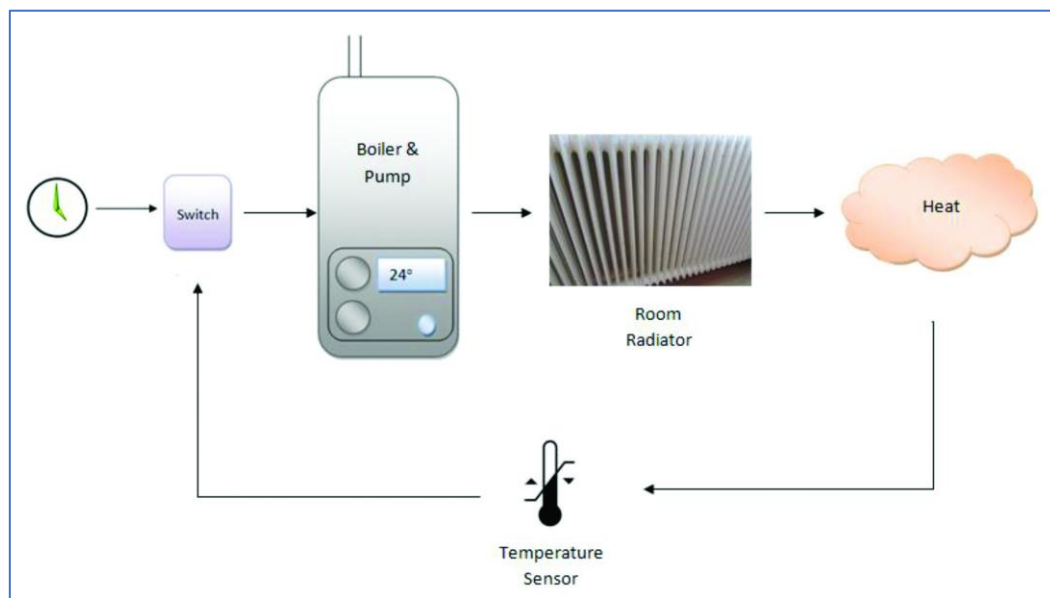
Systems are often categorised as open or closed. But what does this mean?

A closed system has specific characteristics. These include:

- The system has a feedback element (for example a thermostat controlling the temperature of a room, or a sensor that adjusts the water level in a tank)
- The system is self-correcting and it keeps the processes working to meet specific pre-set targets (for example the temperature must be maintained at 24 degrees - 24°)
- The only thing that goes into or out of a closed system is energy
- The system is accurate and reliable
- To preserve accuracy and reliability the system needs to be maintained (such as checking thermostats and timers work correctly)

Modern central heating systems are a good example of a closed system.

Once switched on (activated by a timer), the system will continue to operate switching on and off, responding to the room temperature.



Central heating system






An open system also has specific characteristics. These include:

- No feedback element. The process continues regardless of any factors.
- A washing machine completing a cycle even if the clothes were clean halfway through the process, or a hair dryer continuing to blow hot air even though the users' hair is already dry
- Open systems require some sort of interaction with their environment - such as the variables added to a washing machine (clothes, washing powder, electricity)
- The systems will not self-correct. Open system will complete the process regardless of any other factors
- The systems are not accurate. Open system cannot know when to stop as there is no feedback into the process
- These systems are also unreliable. A tumble dryer could finish its timed run with the clothes still wet

Examples of open systems are:

- Washing machine
- Tumble dryer
- Hair dryer

Work with a partner to consider the following systems. Are they open or closed? Why?

System	Open or closed?	Why?
Iron (to iron clothes) 		
Saucepan boiling water 		
The human Body 		
Car air Conditioning 		
Pond 		

Share your answers and 'why?' information with your class.

## Guidance notes for teachers

### Activity 1

This lesson is designed to give students a broad, high-level understanding of open and closed systems and the differences between them.

Ensure students understand the main characteristics of each type of system by working through the student book information and adding or eliciting any other suitable examples.

Encourage students to work in pairs to decide which of a series of systems would be classified as open or closed. Before starting ensure that students understand what each system is. If any systems are unfamiliar to learners you may choose to replace them with other, more familiar examples.

Here are the answers to the systems provided in the table.

System	Open or closed?	Why?
Iron (to iron clothes)	Closed	Once switched on a thermostat manages its temperature
Saucepan boiling water	Open	The water is placed in the saucepan and the heat is switched on - it will not switch off until someone removes it from the heat
The human body	Open	Different foods and liquids are input and there are bodily outputs - so the body interacts with its environment
Car air conditioning	Closed	The sensor in the car will keep the temperature constant
Pond	Open	External variables such as heat, light and other matter such as insects and equally insects can come out of the pond - there is nothing monitoring the pond that will change its behaviour

Conduct a whole class feedback, correcting any errors or misconceptions as they arise.

### Resources

- Computers with Internet access

### Terminology

- Predictable** - known in advance and unlikely to change

## Lesson 18 – Expert Systems

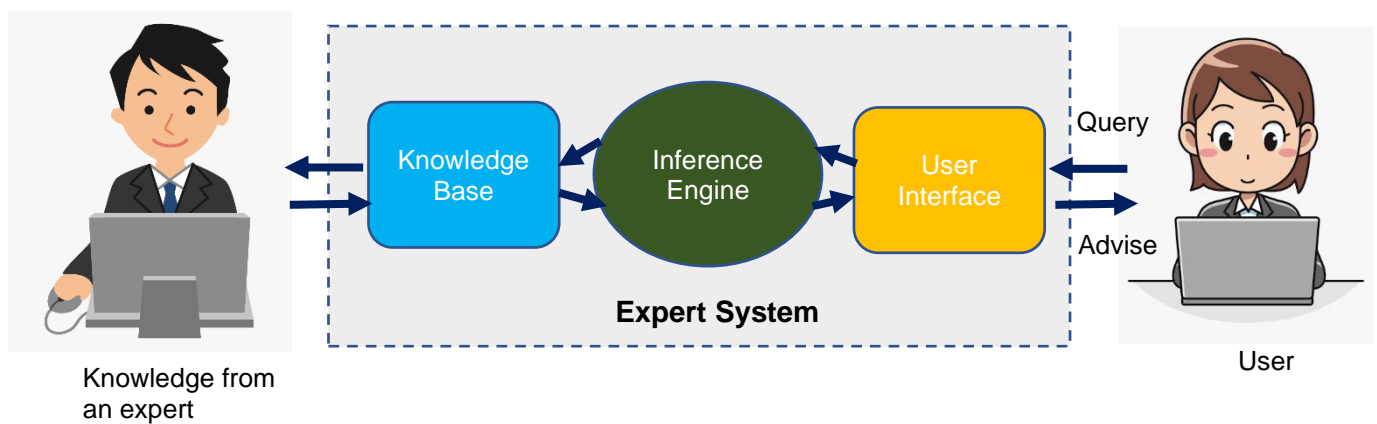
**By the end of the lesson you will understand:**

- Expert system and its main components
- How expert systems are used

An expert system is a computer system that uses artificial intelligence technologies to solve complex problems and to provide decision making ability at a human expert level. Expert system solves problems based on the knowledge acquired from experts. The knowledge and expertise acquired are stored in the form of specific rules and are distinguished by the clean separation of knowledge and the reasoning mechanism.

### Main Components of An Expert System

An expert system has three components: the knowledge base, the inference engine, and the user interface.



**Knowledge Base:** Knowledge base is the most important element of an expert system. Knowledge base stores knowledge acquired from experts of the particular domain. The knowledge is represented as a set of rules which consists of two parts: the IF (condition) part and the THEN (action) part. When the condition part of a rule is satisfied, the rule is fired, and the action part is executed.

**Inference Engine:** Inference engine is the brain of an expert system; it carries out the reasoning whereby the expert system reaches a solution. The inference engine acquires relevant data from the knowledge base, interpret it, and find a solution to the user's problem.

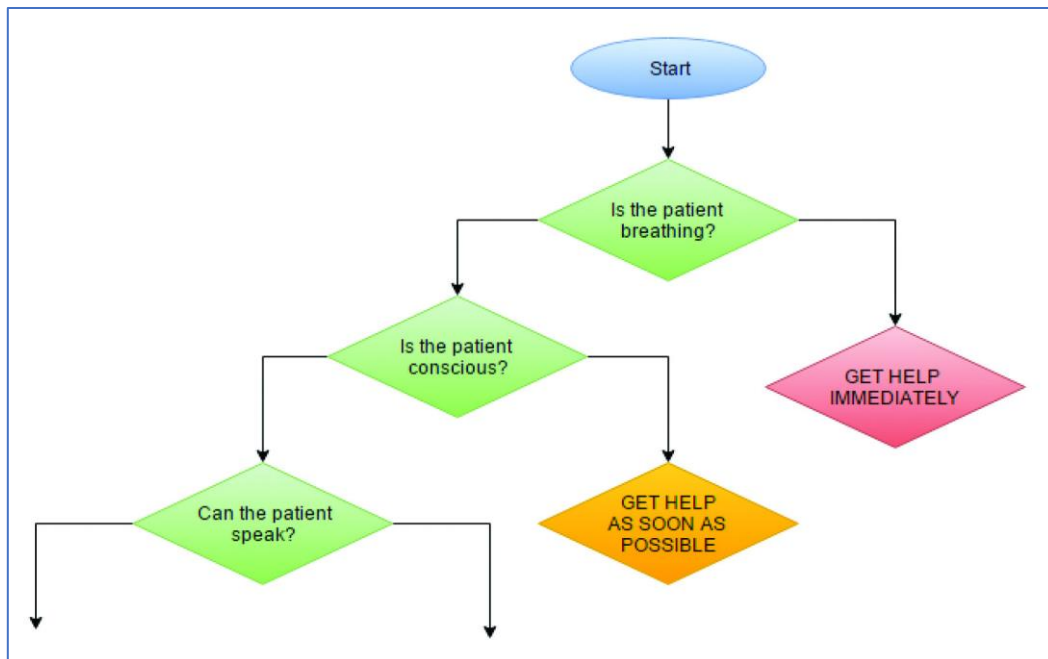
**User Interface:** The user interface is the means of communication between a user seeking a solution to the problem and an expert system. The user's query is entered via the user interface and the solution to the problem will be displayed to the user via the user interface.

## Activity 1

Expert systems are a form of Artificial Intelligence that can be used by non-experts to help them answer questions and make decisions.

Areas where expert systems are used include:

- Help desks
- Government advice services
- Medical diagnoses
- Car repairs



Expert systems work by using a **knowledge base** which contains facts and an **inference engine** which applies rules and manages access to the facts.

For example, medical helplines usually begin with a question such as “Is the patient breathing?”

The next question is selected by the inference engine based on the answer to the previous question.

The inference engine may also advise as to what action needs to be taken and when.

There are lots of advantages to operating an Expert system:

- The knowledge base is easy to update
- Advisers don't need to be retrained every time there is a new development
- The expert advice is available 24/7
- The system does not get tired
- The system uses logic and there is no emotion in the decisions that are made
- The system can be used as a training aid

Can you think of any disadvantages?

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## Activity 2

Your teacher will give you a link to an online symptom checker.

Make up some basic symptoms and click on search.

Review the results based on your input.

The results in the list will match the symptoms you entered.

Serious conditions that require immediate medical attention are marked with a red flag.

Each condition can be expanded for more information.

You may be a little alarmed by some of the conditions that are suggested!

How accurate do you think the symptom checker is?

## Guidance notes for teachers

### Activity 1 - Pair and whole class activity

Introduce the concept of using Artificial Intelligence to answer questions in an expert capacity. Discuss the contexts in which medical expert systems are used and the associated advantages.

The students discuss the potential disadvantages in pairs or small groups. Suitable answers include:

- They are not much use without an extensive knowledge base
- Systems can take time to build and can be expensive
- Expert systems cannot deal well with ambiguous information
- Unlike people, expert systems do not learn from their mistakes
- Expert systems cannot think creatively

### Activity 2

Encourage students to work with a partner and use a symptom checker. The following is suggested although you may choose any suitable alternative:

<http://patient.info/symptom-checker>

The students should enter some basic symptoms into the checker and discuss the results with their partner, completing the questions in the student book.

Broaden the discussion to include the whole class. The following points may be raised:

- The information could be misconstrued by users, due to a lack of medical understanding.
- Is the system reliable?
- Does the system accept any accountability or liability for a misdiagnosis?
- How much do learners trust the information that is provided by the system?
- How reliable is it?
- Should health organisations save money by employing fewer medical staff and installing expert systems?

End the lesson by posing the question, 'Do the benefits of an expert system outweigh the potential problems?' You may choose to elicit the view of the class with a show of hands.

### Resources

- Computers with Internet access

### Abbreviations

- **24/7** - 24 hours per day, 7 days per week

### Terminology

- **Diagnosis** - the process of working out the cause of a problem
- **Disclaimer** - a warning statement declining responsibility for the way a product is used
- **Triage** - the process of deciding how serious a patient's condition is



## Lesson 19 – Training Simulations and Virtual Reality

**By the end of the lesson you will understand more about:**

- Virtual Reality and Augmented Reality
- How simulations are used in work environments

Virtual Reality (VR) is the use of computer technology to generate three-dimensional simulated environment that does not exist. This computer-generated digital environment is experienced through sensory stimuli such as sights and sounds. Virtual reality enables users to physically walk around objects and touch those objects as if they were real. User immerses in the VR environment that simulates reality through the use of interactive devices such as VR headset, VR gloves, VR glasses, and etc.



Augmented Reality (AR) involves overlaying visual elements, sound, or other sensory information over the real-world environment. AR is way of viewing the real world by enhancing visuals with computer-generated inputs such as still graphics, audio, or video. The game Pokémon Go is a good example of AR where Pokémon appears anchored to the real-world environment right in front of the user.

The two main differences between VR and AR are:

- VR is simulated virtual environment while AR is dependent on real-world environment.
- VR needs dedicated devices for user interaction while AR can be accessed via a smartphone or tablet.

VR replaces reality by bringing users into the virtual world, whereas AR adds to reality by projecting information on top of what the user sees in the real world.

There are many great VR and AR games available in the market today, but VR and AR's potential does not stop there. Many industries are already adopting VR and AR such as:

- Healthcare: VR has great potential as a teaching medium in the medical field. Healthcare professionals now use virtual models to prepare themselves for working on real bodies and practitioners can use VR to practice surgery and procedures.
- Retail: With the use of AR, customers can locate items faster in a store, scan items to view information, or even dress up a simulated model so customer can see how garments look in different body shapes.
- Education: Schools, colleges, and universities now adopt VR in education for teaching and learning situations. VR allows students to learn in an immersive and experiential way. Educators can utilise VR in an educational setting by exploring historical simulations such as a VR museum field trip during history lesson.

## Activity 1

Simulations are used in training for many jobs, especially where there is an element of danger and risk for the employee and others.

As technology advances, simulations are becoming more sophisticated and more realistic. Trainees can even interact with the simulation and affect the outcome.

Watch the video about how simulations are used to train workers.

Make a list of other occupations you think benefit from using a virtual training environment:



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Working in a group, investigate the simulation your teacher gives you.

Discuss your ideas with your group and answer the questions below.

Occupation:

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What are the advantages of using simulation in this environment?

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Are there any disadvantages?

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What are the key features of this simulation?

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**Rate This:**

How would you rate this simulation:  
**Poor   1   2   3   4   5   6   7   8   9   10   Excellent**

## Activity 2

Virtual Reality (VR) already has the power to place employees in all kinds of situations, enabling them to carry out particular tasks and test response times.

VR is also being used more and more for entertainment and gaming.

### Video

Watch the video about virtual reality and discuss the tasks the people in the video perform with your group.

**How do you think VR is going to change training people in the future?**

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### Activity 3

Share your findings from Activities 1 and 2 with the rest of the class. Identify at least two advantages and at least one disadvantage of occupational simulation:

#### Advantages

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

#### Disadvantages

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

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## Guidance notes for teachers

### Activity 1

The activity begins with the learners watching a 1 minute 30 second YouTube video containing a news report about how simulation is being used to train and assess police firearms officers. Learners should watch the video as a class and briefly discuss it - ensuring that learners notice the fact that the simulation is completely interactive.

Simulator trains police in dangerous situations (1.30 min):

<https://www.youtube.com/watch?v=HNzR4I1VGPK>

Split the class into small groups of 3-4 and allocate one of the following links (suggested) to each group. The students should explore the simulation and reflect on how simulations are used in that particular industry.

Encourage students to work together as a group to complete the questions in the student book.

#### Heart Surgery

<http://www.silvergames.com/en/heart-surgery/iframe>

#### Fire fighting

<http://www.designingdigitally.com/portfolio/training-simulations/firefighter-training-simulation-revas-process#axzz4S98vfhm2>

#### Crane driver

<https://www.youtube.com/watch?v=-ykGcjmUqYY>

#### Mining

<https://www.youtube.com/watch?v=PFVUqy3a6WQ>

#### Baltic Aviation Academy: Pilots Training in Full Flight Simulator (FFS):

<https://www.youtube.com/watch?v=QqNy3CfIM4c>

### Activity 2

Show the following video, or suitable alternative:

<https://www.youtube.com/watch?v=qYfNzhLXYGc>

The students discuss the potential use of VR in job training and make notes as to how they think VR may be used in the future.

### Activity 3

Bring the class back together and discuss the advantages and disadvantages of occupational simulation.

Create a list of advantages and disadvantages on the whiteboard, for students to record in their books. Suitable answers are given below:

#### Advantages

- Employees can practice without putting themselves or others at risk
- Different scenarios can be simulated to give employees a wider range of experiences
- Scenarios can be repeated
- The employee's behaviour can be studied as well as the physical responses in relation to the job

#### Disadvantages

- Creating the models can be time consuming
- Models should be thoroughly tested before being used
- Some situations are difficult to model
- Models cannot test for every situation

#### Resources

- Computers with Internet access

#### Abbreviations

- **VR** - Virtual Reality

#### Terminology

- **Occupation** - job

## Lesson 20 – Using Simulation in Research and Development

**By the end of the lesson you will understand:**

- How simulation is used in research and development
- How 3D printing is used to simulate products

Modelling and simulation are used in many research and development fields, they are used in various areas to help with decision making including weather forecasting, finance and the aviation industry. Below are some examples of using modelling and simulation in research and development.

For example, aviation engineers are asked to design a new aeroplane that will go faster at a lower cost. However, it is too costly to build all aeroplane designs for testing. To solve this issue, the aviation engineers develop computer models to predict how aeroplanes will fly and then they run simulations of the different aeroplane designs. In the end, the aeroplane with the best results during the simulations is built.

Other fields also face similar problems which they need to provide solutions for. For example, in pharmacology (the study of drugs and actions on living organism), project teams are often challenged when it comes to determining the best design for a clinical trial. There are many questions that need to be answered, such as:

“What dose should be administered? How long should the treatment duration be? How many patients should be tested? etc.”

But not all scenarios can be tested. In such situations, modelling and simulation approaches can help the teams design the best studies.

Likewise, simulation and computer modelling can be used in drug development to help project teams make more informed decisions. Computer models and simulations can predict the outcomes of different clinical trial design options. For instance, if a pharmaceutical firm wants to introduce a new drug, they will want to know how long the clinical trial should last to conclude the drug efficacy is superior to the current standard of care.

Models use mathematical equations to describe and link the different pieces of information together. It usually takes weeks or months to develop a model depending on its complexity. As new pieces of information become available, models are updated. Once a model is found to properly predict known system behaviours such as reproducing observed efficacy to current treatments, it is then used for simulation.

In simulation, ‘what if’ questions are addressed, for example, what would the expected efficacy be if the study was shortened by three months? And, what would the effect of the drug be if eight different doses were used? By simulating different scenarios that cannot be tested in a clinic, clinical pharmacology contributes by saving time and costs, while ensuring the robustness of the study design.

Now that project teams have seen first-hand how modelling and simulation can help them design informative studies, they now know how long their clinical trials should last, what the expected efficacy would be and what the effect of a different dose will be. They also know that modelling and simulation can also address challenges beyond clinical trial design options such as a target identification, disease understanding, competitor comparison and the probability of success in late stages.



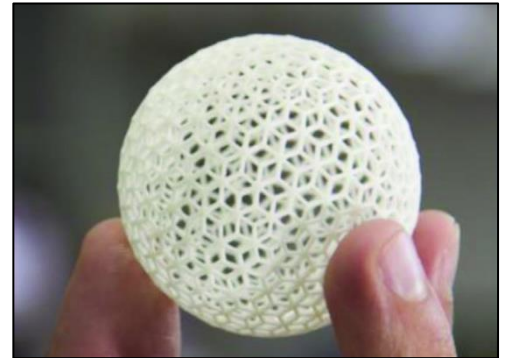
## Activity 1

### Video

Watch the short video about the process of 3D printing.

Traditionally, engineers have made prototypes of products as part of the research and development process.

Developments in 3D printing technology have significantly reduced the cost of producing accurate and realistic models.



Potentially, 3D printers may be able to print spare parts and tools for a range of technologies.

There is some debate about how effective these products are and how likely this is to happen.

The example on the left is an adjustable wrench that has been created using a 3D printer. It is a fully working wrench with a working adjuster.

## Activity 2

### Class Debate

You are going to take part in a class debate of the following statement: "3D printing is the future of parts development and distribution".

You teacher will split the class evenly so that both sides of the argument are covered and give you a link to use to prepare for the debate.

You may not be allocated to the side you agree with. This is a useful skill and to learn!

At the end of the debate take a vote on whether the future of parts replacement should focus on 3D printing.

Was the statement accepted? \_\_\_\_\_

## Guidance notes for teachers

### Activity 1

Show the following video (or suitable alternative):

<http://3dprinting.com/what-is-3d-printing/>

Explore various ways in which 3D printing is applied using the links below:

- <http://www.gizmag.com/stratasys-j750-3d-printer/42611/>
- <http://makezine.com/2011/12/20/best-of-make-3d-printed-objects/>
- [http://www.oddee.com/item\\_98686.aspx](http://www.oddee.com/item_98686.aspx)

Discuss the advantages and disadvantages of 3D printing and how it is used in a research and development context.

### Activity 2

Split the class into two teams and tell them they will be holding a debate on the statement: “3D printing is the future of parts development and distribution”.

Half of the class will support the motion that 3D printing is the future of parts development and distribution; the other half of the class should prepare to argue against.

Give the group who support the motion the following link:

**30 Cool things to 3D print which are actually useful**

<https://all3dp.com/cool-things-to-3d-print-useful/>

Direct the group opposing the motion to this link:

**3D printers are great, but can they really print spare parts?**

<https://conversation.which.co.uk/technology/3d-printing-printer-spare-parts/>

Further guidance on how to run a debate can be found at:

[http://news.bbc.co.uk/cbbcnews/hi/newsid\\_4450000/newsid\\_4458000/4458081.stm](http://news.bbc.co.uk/cbbcnews/hi/newsid_4450000/newsid_4458000/4458081.stm)

Allow the students sufficient time to write their arguments before holding the debate and taking a final vote.

## Resources

- Computers with Internet access

## Abbreviations

- **3D** - 3 Dimensional

## Terminology

- **Prosthetic limb** - artificial limb
- **Prototype** - a working model of a product

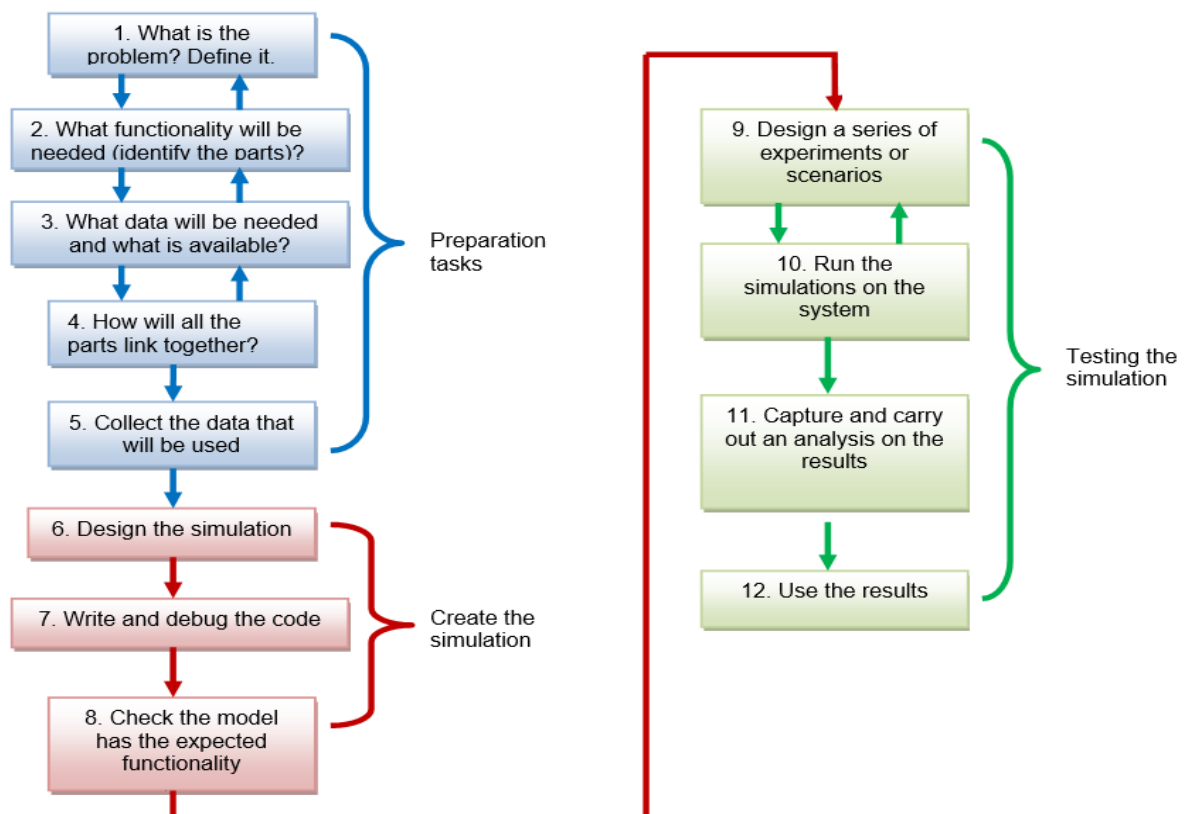
## Lesson 21 – Creating Computer Models

**By the end of the lesson you will understand more about:**

- How computer models are created

Creating a computer simulation is based on a sequence of actions. It is a similar process to creating an algorithm for a computer program.

The following diagram shows the steps for developing a simulation. The process includes preparation tasks, implementation tasks and testing tasks.



Before developing a computer model, we must first understand the problem we want to solve. A detailed problem description helps in defining the boundaries of the system. The problem description should include a set of questions, objectives, assumptions, and performance metrics which will be used in testing the performance of the model. The data which is needed for the computer model must also be clearly defined.

Once we get the detailed problem statement, we can start designing a conceptual model of the system. We can begin with the most basic functions needed for the model and keep on improving it with additional features until we are confident that the model captures the actual system we intended to develop. Based on the conceptual model, the model is encoded in a computer language.

Finally, we can test the computer model and analyse the performance metrics stated in the problem statement. The result of executing the model should be analysed. The reliability of the model depends on the quality and size of the data collected. The computer model is considered successful if the model achieves the intended objectives declared in the problem statement.

### Activity 1

Work in a small group and investigate the PC building simulation software as instructed by your teacher.

Explore each part of the simulation. What does it do? How might it be improved?

**Choose three areas of the simulation that you would like to redesign.**

**Use this space to make notes and record any decisions made by your group.**

**Use this space to represent the process graphically, in a diagram.**

## Guidance notes for teachers

### Activity 1

Work through the diagram with the class and explain the 12 steps needed to create a simulation. Arrange the class into groups of three (suggested).

Working as a group, the students explore PC building simulation of how to build a PC. Download and install the software from the following link.

<https://steamunlocked.net/pc-building-simulator-free-pc-download/>

The students should investigate the existing simulation, identify its functionality and suggest three ways in which the simulation could be improved.

You may offer the following suggestions to any students struggling with this activity:

- The hardware images could be updated.
- The motherboard could have onboard sound and graphics in which case plug in sound cards are not required.
- The user could complete an activity where a processor needs to be matched to the correct motherboard.

Take feedback from each of the groups and record their ideas on the whiteboard.

**Extension/plenary:** There is space allocated in the student book for you to extend able students with an additional task. The students should pick one of their suggestions and develop their idea, creating a series of linked, annotated drawings demonstrating the process. Dependent upon the level of skill, students may also wish to create mocked-up screens to illustrate their ideas and describe how they would improve one aspect of the simulation.

### Resources

- Computers with Internet access

## Lesson 22 – Data Validation

### By the end of the lesson you will know:

- How to validate input in a spreadsheet
- How to improve the accuracy of a spreadsheet

Validation is the process by which the modeller and the client satisfy themselves that the model is suitable for use within its defined experimental frame. Data validation is a must to ensure that the model is wholly adequate and appropriate for the task for which it is intended.

To most of the people, data verification and data validation may sound like they are the same thing, but the fact is they are distinctly different. Data validation makes sure the data entered is correct and valid. Data validation ensures the logical consistency of input and stored data. Data validation checks that the data entered follows the rules set up for the data during data input stage. For example:

- Age must be numeric and between the range of 0 – 120.
- Date of Birth can be validated using dd/mm/yyyy format.
- Email address must contain a @ and a . (dot).

Data verification is the process of checking the sensibility of data entered. Data verification is to ensure the current data stored is accurate. Data verification may happen at any time, and it is an ongoing process to ensure data quality. Examples of data verification:

- To verify the age entered by the user, we can check against a valid document such as passport.
- To verify the mobile phone entered by the user, the user will receive a SMS containing a pin code for verification purpose.

A spreadsheet is one of the most common tools used to build computer models. It provides a convenient and useful way for businesses to implement computer models. Spreadsheets come with comprehensive data validation features to restrict incorrect data entry. Using data validation will allow us to control the data that is typed into the model and avoid errors.

Below are some examples of data validations that we can apply to our spreadsheet model:

- To create a drop-down list – For example, we can create a list containing all the states of a country.
- To restrict numbers outside a specified range - For example, we can specify the range of discount percentage only allow a whole number between 0 and 15.
- Use check boxes that can help users choose their desired options from a list – For example, a list of books that purchaser can choose and tick.
- To restrict times outside a certain time frame – For example, working hours is between 9.00 AM to 5.00 PM.
- To restrict dates outside a certain time frame – For example, a cake delivery date must be today's date or a future date.

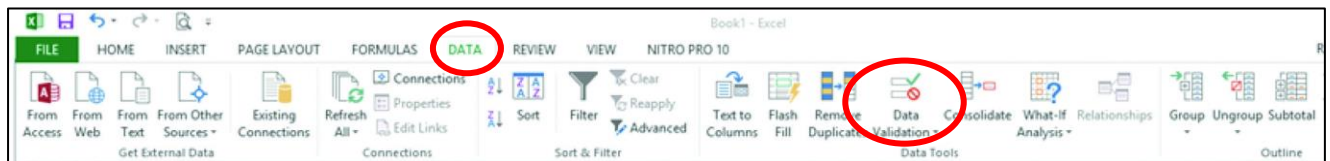
## Activity 1

Many organisations use spreadsheets to monitor their activities and finances. This may include using simulated spreadsheets for training purposes.

Working with data tables and lots of text can be difficult. It is easy to make mistakes.

Input errors are common; data may be mistyped, put in the wrong column or left out entirely.

One way of reducing the errors in a spreadsheet is to control the data input using the Data validation tool which can be found in the Data tab. Here is an Example from Excel:



## Let's Practise

You are going to validate three different types of input and range.

### Age Validation

We can make a number of assumptions about setting a value for age:

It cannot be a negative value.

It is unlikely to exceed 120 years. Sometimes people live a very long time but it is unlikely to be more than 120.

However global life expectancy ranges from 53 – 83 years.

Most people give their ages as a whole number when asked e.g. 'I am 23' not 'I am 23 years, 4 months and 6 days old'.

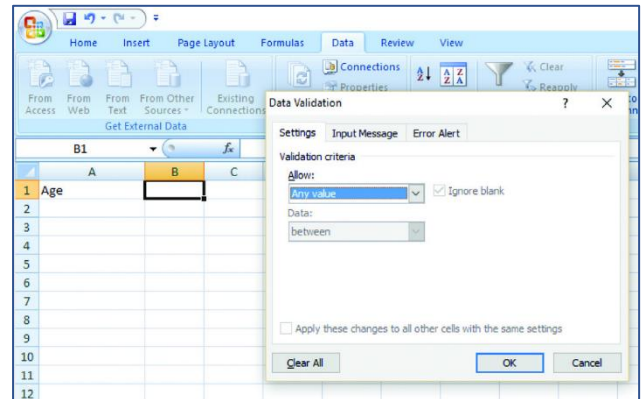


Open a new spreadsheet and type the word, Age, in cell A1.

Now click cell B1, open the Data tab and select Data Validation.

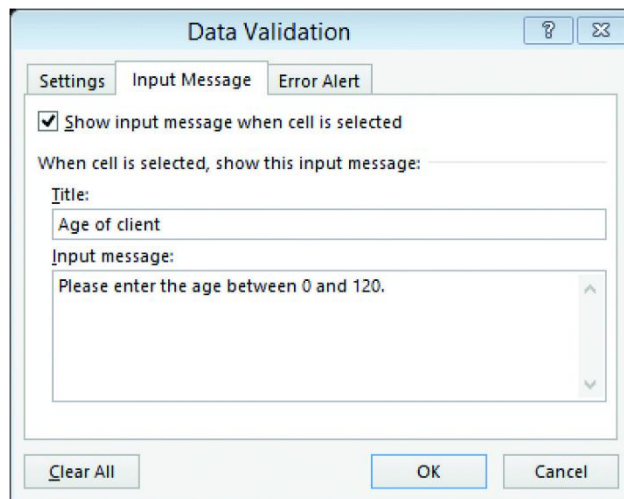
A dialogue box will appear on your screen with the default setting, *Any Value*.

When you click on the dropdown box you are presented with a list of data types. Select *Whole number*.



The drop-down menu under Data gives a list of relational operators, for example greater than, less than, between etc.

Select **between** from the list and set 0 as the minimum and 120 as the maximum.



Don't close the dialogue box yet! You need to add an Input Message for the user.

Type Please enter the age of the client between 0 and 120 into the *Input Message* section of the dialogue box.

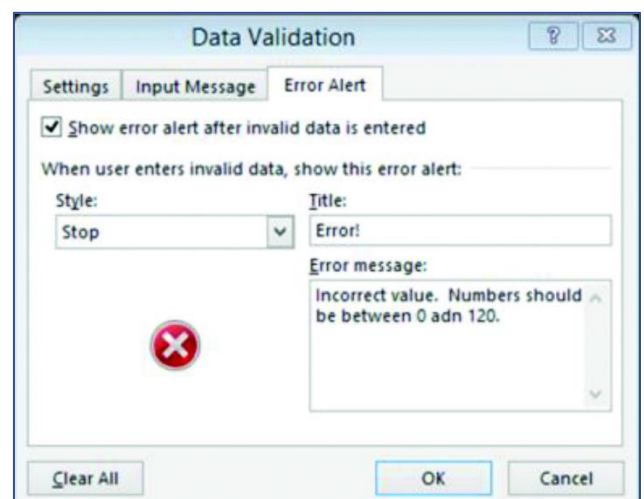
Finally, in the third tab along, enter an error alert.

Click OK to close the dialogue box.

When cell B1 is selected an input message will now appear.

If the user attempts to input an invalid number an error message will show, prompting them to input a number from the correct range.

Test your spreadsheet by inputting both correct and incorrect values.



## Text Validation

Type the word Name into cell A3.

Select cell B3 and open the Data Validation dialogue box again.

This time you are going to set a limit on the text length to 15 characters.

Remember to add an input message and an error message.

Add some text to test the validation.

## Date Validation

Type the word Date into A5.

Set the value for the date in cell B5 to after 31/12/15 and add an input message and an error message.

See what happens if you add a date prior to 31/12/15.

Design and add an additional validation in cell B7.

## Activity 2

Validating user inputs improves the efficiency of a spreadsheet. However, it still needs to be monitored and checked for accuracy.

What method would you use to test the results of a spreadsheet?

Use a spreadsheet to work out this calculation.

$$25 + 17 / 2 * 8$$

Answer: \_\_\_\_\_

Now work out the same sum using a calculator:

Answer: \_\_\_\_\_

Finally check the calculation using a written method:

Answer: \_\_\_\_\_

**Use this box for your working out:**

**Why do you think the spreadsheet  
gives a different answer to the other two methods?**

**Discuss how to solve this problem  
with the person next to you and write the solution here:**

Does the answer on the spreadsheet now match the calculator input and your handwritten answer?

## Guidance notes for teachers

### Activity 1

Discuss when spreadsheets are used in a business context and the potential for user error.

Work through the three examples of validating data with students before setting them to work independently, creating a validation of their choice.

#### Age

Discuss the values for age range with the class in the context of current global data:

- [http://www.who.int/gho/mortality\\_burden\\_disease/life\\_tables/situation\\_trends/en/](http://www.who.int/gho/mortality_burden_disease/life_tables/situation_trends/en/)
- <http://www.guinnessworldrecords.com/news/2016/11/worlds-oldest-person-emma-morano-turns-117>

The example in the student book gives a range of 0 – 120. You may wish to change this based on the outcome of the class discussion.

#### Text

The students set a limit of up to 15 characters on the input value.

Ask the students what would happen if the criteria was set to “= to 15 characters”. - *Values shorter than 15 characters would also be rejected.*

#### Date

Ask the students whether they have used a system that requires a valid date to be entered.

Examples include cinema and holiday bookings.

Emphasis the point that validation improves the efficiency of models and simulations by ensuring that accurate data is used.

### Activity 2

Ask students to work out the calculation  $25 + 17 / 2 * 8$  using the spreadsheet.

They should arrive at the value 93.

The students then use a calculator and work out the sum using a written method. They should arrive at the answer 168.

The students discuss their results with a partner and work to resolve the problem.

#### Solution:

Computers use BODMAS to manage the order of precedence when calculating a sum.

The user needs to input = SUM (25+17)/2\*8

$25 + 17 \div 2 \times 8$  becomes  $(25 + 17) \div 2 \times 8$

### Resources

- Computers with access to spreadsheet software

### Terminology

- **Range** - a series of values with an upper and a lower limit
- **Validation** - setting specific values or boundaries to control what a user can input on a spreadsheet

## Lesson 23 – Evaluating Computer Models

**By the end of this lesson you will know more about:**

- How to check that a model or simulation meets its objectives

To check that a model or simulation meets its objectives you have to be clear what the objectives are from the start.

Many developers set SMART objectives at the beginning of a project. SMART is a technique used to help organisations and individuals set objectives in an effective and productive manner. It is easy to set S.M.A.R.T objectives, write down the desired outcomes and set a deadline for achieving them. SMART stands for:

### **S - Specific:**

Objectives should be specific and well-defined. A clear and well-defined objective is important because when you reach the milestone, you will certainly know you have achieved your objective.

Consider these prompts:

- Who is the product for and what it is meant to do?
- Who will be involved?
- What you want to accomplish?

### **M - Measurable:**

The objectives must include a measure for monitoring the progress, impact, or success. The measure of project can be related to a percentage, a frequency, rate, or number. For example: "Reduce operational cost by 15%".

Consider these prompts:

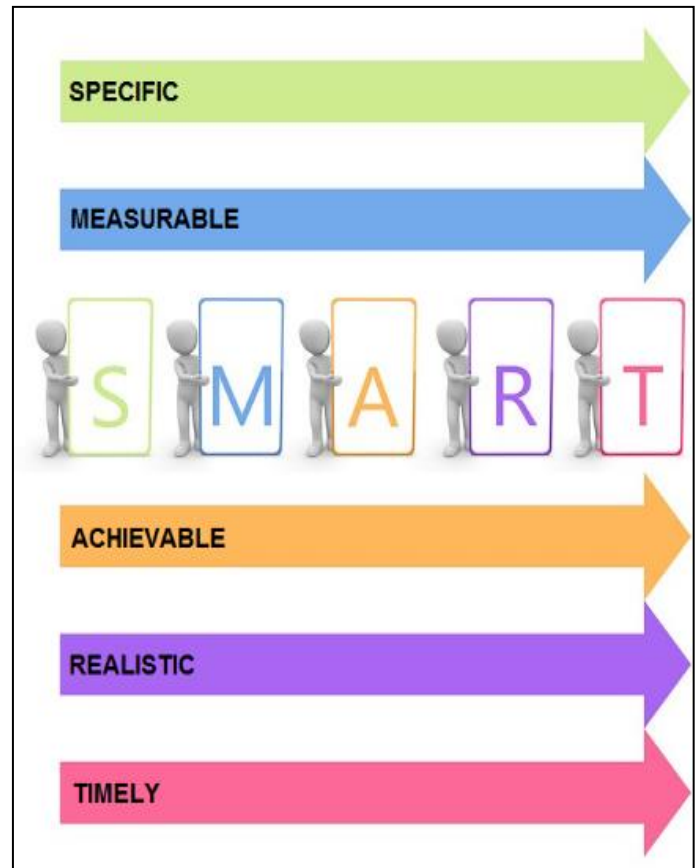
- What difference is the product going to make?
- What is the measurable outcome?

### **A - Achievable:**

The objectives must be feasible and within the limit of the team. Design the objectives to be challenging, but never set objectives which are impossible to complete. Ask yourself a question: "Is the objective is something that can be reasonably accomplished?".

Consider these prompts:

- Are there enough resources (like time and money) to finish the project?
- Do we have the necessary skills to do the task well?





### **R - Realistic:**

The objectives must be realistic and relevant. Important aspects of setting up realistic objectives are knowing what are the available resources to achieve it and also to take into account any potential obstacles and constraints that may be faced.

Consider these prompts:

- Is there anything that could stop the project being completed?
- Is the objective realistic and within reach?

### **T - Timely:**

It is very important that objectives have a target date when they should be completed. A date must be set by when the outcome must be achieved. Objectives should have time-related parameters built in, so that everyone who is involved in the project has a clear idea of the designated timeframe.

Consider these prompts:

- Can it be done in time? The development plan may have extra time for any unknown issues.
- Is this timeframe realistic?

## **Activity 1**

### **Let's Check Together**

You teacher will give you a link to an online model or simulation. Use the simulator and decide whether it meets its intended objectives.

Run the simulation and answer the following questions:

**Does the simulation provide the user with a basic understanding?**

**Is the simulation easy to use?**

**Are the objectives measurable? Does the user end up with the information they require?**

**What are your conclusions? Is the simulator effective? Why or Why not?**

## Guidance notes for teachers

### Activity 1

Discuss and work through the concept of SMART objectives with the class. The suggested simulator for this activity is based on loans with interest. However, this is not explicitly stated in students' books, allowing for a suitable alternative simulator to be chosen if necessary.

Provide students with a link to a simple loan calculator tool. The following is suggested although you may choose any suitable alternative:

<https://www.bankrate.com/calculators/savings/simple-loan-payment-calculator.aspx>

Take a little time to explain to students how a loan calculator works, i.e. used to show loan repayments based on the amount of money borrowed, interest rate and repayment period.

The students assess the effectiveness of the loan calculator based on the following questions:

- Does the simulation provide the user with a basic understanding of finance and borrowing?
- Is the simulation easy to use?
- Are the objectives measurable? Does the user end up with the information they require?

Discuss the results of the students' investigation as a class. You may wish to raise the following points for discussion:

- Is it easy to find an exact value using the slider?
- It is not made obvious to the user that they can click in the boxes and key in a value.
- There is no glossary to explain financial terms such as loan rate, interest rate and APR.
- How useful is the help tab?

### Resources

- Computers with Internet access

### Abbreviations

- **ATM** - Automatic Teller Machine
- **APR** - Annual Percentage Rate

## Lesson 24 – Improving Computer Models

**By the end of the lesson you will understand:**

- How to improve a computer model or simulation

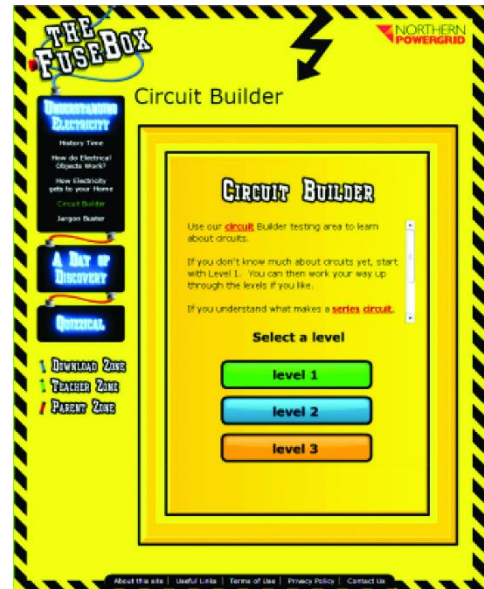
After evaluating a computer model, now is the time to improve the model based on the evaluation findings. Complete the following Activity 1 and Activity 2 to get yourself familiar with how to improve a computer model.

### Activity 1

Use the simulator your teacher shows you.

Your teacher will tell you which part of the simulator you should test.

When you have had a go at using the simulator, work with a partner and answer the following questions.



What do you think about the user interface design? How effective is the layout?  
Is the text easy to read?

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What is the impact of the colour scheme on the user? Do you like it?

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Is the content educational? Is it easy to use?

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Could the simulation be improved? Yes/No. Why?

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Your teacher may ask you to discuss your findings with the rest of the class.

## Guidance notes for teachers

### Activity 1

Encourage students to think about the user's experience when they use a simulation.

What effect does an interface have on a user? How do colours, fonts and layout impact a user's experience?

Discuss the theory that colours provoke an emotional response, for example red is sometimes associated with anger and blue is widely considered to be calming.

Some colour combinations may be harder for people with a visual impairment or dyslexia to read.

<https://www.viget.com/articles/color-contrast>

Direct students to the following suggested link:

<http://thefusebox.northernpowergrid.com/page/circuitbuilder.cfm>

or alternative:

<http://powerup.ukpowernetworks.co.uk/powerup/en/over-11/circuits/circuit-builder/>

Arrange the class into pairs and allocate one of the activities from the Understanding Electricity or A Day of Discovery sections to each pair.

Allow the students sufficient time to explore the simulation and answer the questions in the student book. Discuss the students' opinions as a class. You may wish to use the following prompts:

- Why is the colour scheme so bright? Is it too bright or is it appropriate to the content of the site?
- Have the developers made effective use of the available space?
- How easy is it to read the instructions?
- Does the user need to scroll the text?
- How easy is it to use the timeline on the Understanding Electricity - History Time option?
- Which electrical objects work best in the How do electrical objects work section?
- How effective is the Day of Discovery section? What age group is it aimed at?
- To what extent are all these opinions subjective?

### Resources

- Computers with Internet access

### Terminology

- **Subjective opinion** - a view based on personal feelings or taste

## Lesson 26 – Planning Research

### By the end of the lesson you will know:

- How to conduct a simple independent research project
- How to record and analyse a set of data

### The Importance of Doing Research

Research is an integral part of many careers in today's world and it is also useful in building up individual skills up at various levels. Getting a job in most industries is becoming increasingly challenging and competitive. New graduates need publications, research and extracurricular activities that enhance their skills and distinguish them from others. By conducting research, you will get the opportunity to present, publish and share your findings with the world. Doing research improves many aspects of the researcher such as laboratory skills, statistical knowledge, critical appraisal skills, better understanding of research papers, ability to organise and plan, developing communication and negotiation skills with peers and, the possibility of getting an academic job.

There are different reasons for conducting research, one reason might be to undertake a project as part a programme of study, another reason might relate to aspects of a job role. Before conducting research, it is important to think for the five 'Ws':

- What? – What is the research about?
- Why? – Why do you want to do the research?
- Who? – Who will be your participants?
- Where? – Where are you going to conduct the research?
- When? – When are you going to do the research?

However, there are possibilities that when conducting research, problems and issues may arise, for example, an outcome is arrived at that wasn't expected, or the researcher is exposed to the laboratory's harmful chemicals (if laboratory work is involved), or the completion cost and time may be higher and take longer than expected, etc. The table below shows the potential problems and possible solutions during conducting research.

### Some Potential Problems During Conducting Research and Possible Solutions

Problem	Solution
Financial strain	Estimate the approximate cost and get a grant before you start
Negative/unexpected outcome	Repeat the experiment
Technique may not work	Seek advice before you start any new technique
Delay in getting device, equipment, or system	Plan ahead and order in advance
Faulty machinery/apparatus/tools	Check all tools before you start the experiment



## Activity 1

You are going to conduct research to see if an online random number generator is truly random, or if it follows a pattern.

Your teacher will ask you to work in a group and show you the number generator to use.

Make sure each member of your group sets the same minimum and maximum.



Click the Generate button 50 times and record the values in the table below.


Count the number of values from 1 – 10	
Count the number of values from 11 – 20	
Count the number of values from 21 – 30	
Count the number of values from 31 – 40	
Count the number of values from 41 – 50	
Which numbers are repeated?	

	Name:					
	Name:					
	Name:					
	Name:					
	Name:					
	Name:					
	Name:					
		Numbers 1 - 10	Numbers 11 - 20	Numbers 21 - 30	Numbers 31 - 40	Numbers 41 - 50

Add up each of the rows and write the total in the end column.

Use the data in the final column to analyse the results by answering the following questions.

In which number category were the <b>most</b> random numbers generated?	
In which number category were the <b>least</b> random numbers generated?	
Was a range of numbers generated an unusually high number of times?	
Did any number category have an unusually low (or zero) outcome?	

Take part in a class discussion and come to a conclusion as to whether the random number generator is truly random.

Is the data you have collected qualitative or quantitative?

---

Is it primary or secondary?

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## Guidance notes for teachers

### Activity 1

Arrange the class into groups of 4-5 students.

Each student works independently, gathering data using a random number generator. The following may be used, or any suitable alternative: <https://www.random.org/>

When each member of the group has collected their data and counted the results for 50 outcomes, they share and collate the data for the whole group.

Discuss the findings of the class and also emphasise the data collection and analysis skills that have been practiced. What do students conclude about the random number generator, based on their data analysis?

All students should be able to state that the data is quantitative and primary.

### Resources

- Computers with Internet access

## Lesson 27 – Collecting Quantitative Data

**By the end of the lesson you will understand more about:**

- How quantitative data is collected and used

There are two main categories of research: qualitative research and quantitative research.

Qualitative research explores attitudes, behaviour, and non-numerical data. It collects data about lived experiences and emotions through methods. Qualitative research tends to get an in-depth opinion from participants. Fewer people take part in qualitative research, but the contact time with these people tends to be longer. Common data collection method for qualitative research includes interview with open-ended questions, observations, and focus groups.

Quantitative research gathers numerical data which can be measured and produces statistical data. Generally, this type of research is used to find out how many, how much, and how often, etc. Quantitative research reaches many more people, but the contact time with those people is much shorter compare with qualitative research. Quantitative research is conducted by using methods various forms of surveys.

### **Qualitative Research vs Quantitative Research - which one is better?**

Different research methodologies have their own strengths and weaknesses. Neither qualitative research nor quantitative research is better than the other. Quantitative research focuses on numbers and statistics, while qualitative research focuses with concepts, thinking and experiences. Quantitative research is used to establish facts, while qualitative research is used to gather in-depth insights. Both qualitative research and quantitative research are dependent on the skills, training, and experiences of the researcher.

Below is a summary comparison for quantitative research and qualitative research:

	<b>Quantitative Research</b>	<b>Qualitative Research</b>
<b>Data Format</b>	Structured data	Unstructured data
<b>Data Analysis</b>	Statically analysis	Summary analysis
<b>Approach</b>	Measure and test	Observe and interpret
<b>Question Format</b>	Closed-ended	Open-ended
<b>Data Collection Methods</b>	Surveys, questionnaire, experiments	Interviews, focus groups, observations
<b>Outcome</b>	Objective conclusions	Subjective conclusions

## Activity 1

There are many methods of collecting quantitative data.

These range from basic surveys using pen and paper to wearable technologies like fitness trackers that measure values such as heart rate, time and distance.

There are even apps which track the user's mood, or monitor sleep. Many of these apps measure and then store data so that a user can analyse different values against various parameters.

Working with a group, you are going to design an app which collects quantitative data. The app should be for a specified purpose and should have clear, measurable parameters.

First decide on a purpose for your app. What does it do?



Use this space to make notes

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What data should the app capture?

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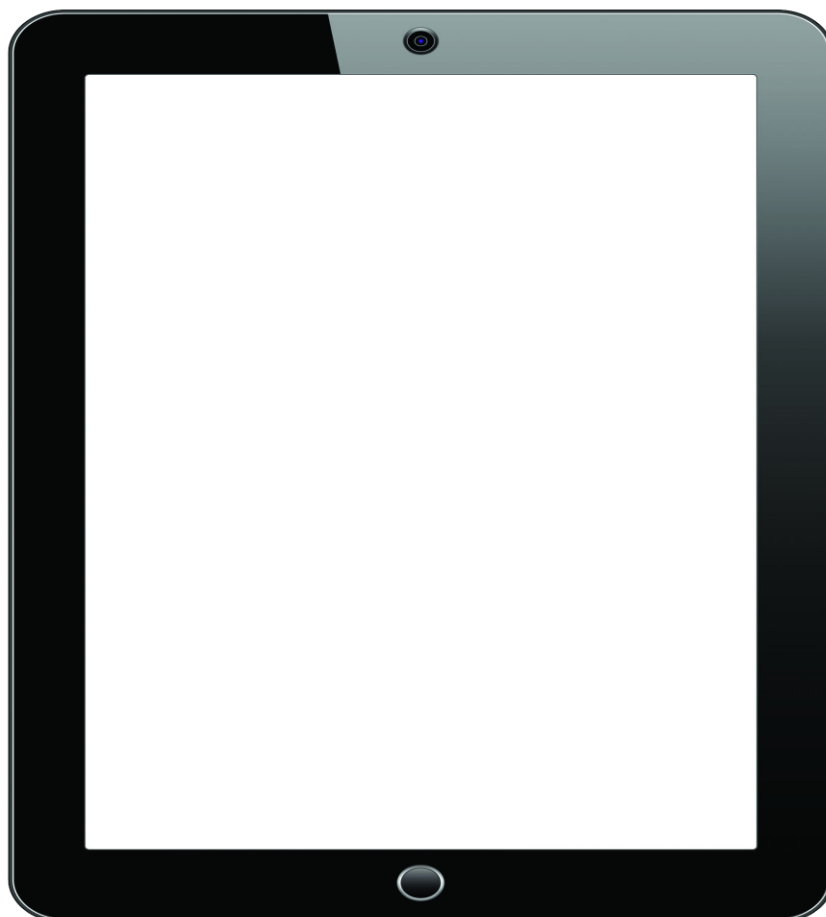
What parameters need to be measured or gathered?

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How will the captured data be used? What should the analysed data tell you?

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### **Let's Present**

Your teacher may ask you to present your group's design to the class.

## Guidance notes for teachers

### Activity 1

Discuss the way data can be collected with the class and record methods on the whiteboard; suitable answers include pen and paper (tally chart), surveys using a point scale (paper or online), interviews and observation, mechanical clickers or abacus for counting objects, wearable devices, medical devices (blood pressure, glucose levels) and phone apps. In the case any students are wearing a fitness tracker, discuss the kind of data it records and how they use it.

Ask the class whether any of them have encountered apps which measure and monitor different activities, such as spending or sleep.

Split the class into small groups (3-4 suggested) and set each group the task of designing an app which tracks quantitative data, using the framework provided in the student book. Remind students that the focus of the activity is team work in deciding the app's purpose, parameters for measurement, look and feel of the user interface.

Allow time at the end of the lesson for each group to present their ideas and designs to the rest of the class.

### Resources

- Computers with Internet access

### Terminology

- **Parameter** - a measurable value linked to a specific circumstance or activity

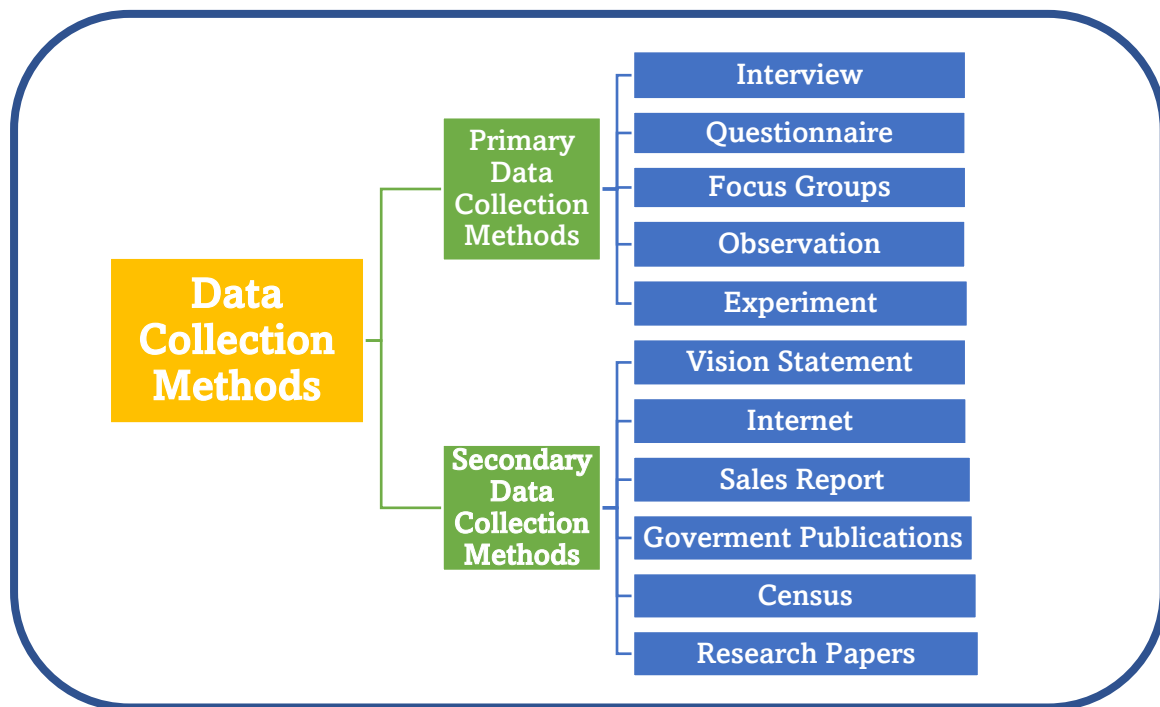


## Lesson 28 – Using Questionnaires and Interviews

**By the end of the lesson you will understand:**

- How to use questionnaires and interviews to collect data

Once we have answered the five ‘Ws’ mentioned in the lesson 26, we can start planning how to conduct the research. The first thing we must decide is the technique for data collection. Basically, data collection methods can be divided to two categories: primary data collection methods and secondary data collection methods.



**Data Collection Methods**

Techniques or tools commonly used for primary data collection include:

- Interviews – There are three types of interviews: unstructured, semi-structured, and structured interviews. An unstructured interview is a type of in-depth interview, whereby questions are not prepared in advanced. In unstructured interviews, the interviewer tends to fully understand the interviewee's point of view by raising questions spontaneously in a free-flowing conversation. A structured interview is frequently used in market research. Questions are planned and created in advanced. All interviewees are asked the same questions. A semi structured interview is the combination of unstructured and structured interviews within which the interviewer asks some prearranged questions with some unplanned questions.
- Questionnaires- A questionnaire consists of predefined questions that are either open-ended or closed, for the purpose of gathering information from respondents. A questionnaire is an economic and efficient way of collecting large amounts of information from a large sample of people.
- Focus Groups – Also called discussion groups or group interviews. A group of people are asked to come together in a group to discuss a particular topic. The researcher acts as the facilitator for the focus group by introducing the topic, asking specific questions, control digressions, and stops break-away conversations.

- Observations – Observation is another way to collect primary data. Observation is a research technique where the researcher watches and listens to a phenomenon as it takes place. During the observation, the researcher has to take notes and/or recording.
- Experiments – An experiment is a primary data collection method of inquiry in science. An experiment is a technique based on laboratory conditions and is conducted in a well-controlled environment. The researcher decides where, when and who participates in the experiment.

### Activity 1

When you are designing the questions for an interview, questionnaire or a survey it is important to be clear about your final objective. What do you need to find out?

The questions should be prepared carefully.

Researchers make decisions about what they need to do and how best to do it.

The first decision is which is the most effective method for gathering the data, for example a questionnaire or an interview?

#### What is the difference?

An interview is a one to one discussion with a respondent carried out face to face or over the phone, or via email using personalised questions.

A **questionnaire** is a series of non-personalised printed questions used to generate answers from respondents. There are a number of different ways to create the questions and capture the data when generating a questionnaire.

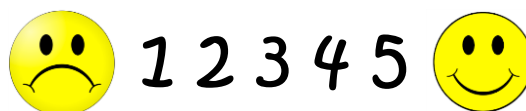
QUESTIONS				
1-	A	B	C	D
2-	A	B	C	D
3-	A	B	C	D
4-	A	B	C	D
5-	A	B	C	D
6-	A	B	C	D

### Creating a Questionnaire

#### Questions using scales

A scale is a way of turning an opinion (qualitative data) into a numerical value (quantitative data). The respondent is asked to rank their answer or how strongly they agree with a held opinion. For example:

How much do you like streaming music on the Internet? Circle one answer.



Can you think of any disadvantages for this method?

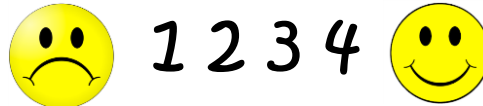
The main problem is quantitative data will not tell you why respondents answer in a particular way or give any in depth insight.

What does an answer of 3 tell you? On a scale of 1-5, 3 is the neutral half way point.

To force the respondent to specify a preference you need to use a scale of 4.

Answer the question again.

How much do you like streaming music on the Internet? Circle one answer.



There is no option of answering with a middle value which means the response has to be positive or negative.

### Using a list

Which of the following activities do you enjoy? Tick all that apply.

- |                         |                          |
|-------------------------|--------------------------|
| Surfing the Internet    | <input type="checkbox"/> |
| Using social media      | <input type="checkbox"/> |
| Playing online games    | <input type="checkbox"/> |
| Watching YouTube videos | <input type="checkbox"/> |
| Streaming music         | <input type="checkbox"/> |
| Sharing photos          | <input type="checkbox"/> |

Is this data qualitative or quantitative?

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Can you think of any disadvantages in using a list?

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The list is fairly limited. It might give you some useful information about whether the respondents enjoy the activities that have been included but it will miss data about other activities that are not listed.

As a researcher, how might you solve this problem?

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### Using ranking

Sometimes a respondent is asked to put their answers in order of preference.

For example, in response to the question, 'Which activities do you like doing best?'

- A Surfing the net
- B Using social media
- C Playing online games
- D Watching YouTube videos
- E Streaming music
- F Sharing photos



the response might be: C D E B F A.

How would you answer the question? Write your answer here:

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Is the data quantitative or qualitative?

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### How might you obtain quantitative data from this survey?

#### **Asking open questions**

Open questions can make analysis difficult because there is no way of predicting how the respondent will reply.

If you asked everyone in your class, 'What do you like doing on the Internet?' you might get many different answers.

How would you respond to this question?

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Was your answer on the list provided previously? Yes/No

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### **Asking closed questions**

Closed questions can only be answered with an option from a given list, or with a yes/no option.

Ranking, lists and scales are all examples of closed questions.

### **Conducting an interview**

**Interviews** are one to one discussions with a respondent and can be structured or unstructured.

A structured interview is based around a planned set of questions. Each respondent is asked exactly the same information using the same wording.

Researchers use structured interviews to ensure they capture the data required.

If an interview is unstructured and the questions have not been prewritten, the interview may take a different direction to that intended by the researcher.

An unstructured interview may not return the required data, however a researcher could discover useful information that they had not previously considered.

What makes a good question? Discuss the answer with a friend and write your ideas down here:

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**When writing questions it is a good idea to avoid certain factors:**

#### **Ambiguity**

An ambiguous question in a survey can be answered in more than one way or it is structured in such a way that the anticipated response is unclear.

How much time, on average, do you spend on the Internet?

**A great deal      A certain amount      None at all**

The scale is ambiguous as “great deal” and “certain amount” are subjective answers. 30 minutes may seem “a great deal” to one person and only “a certain amount” to someone else.

Can you rewrite this question to make it less ambiguous.

### **Memory**

Questions that rely on memory, for example 'How much time did you spend on the Internet the week before last?' do not always get an accurate response.

### **Knowledge**

A respondent is less likely to respond to a question if they need to research the answer.

### **Double questions**

A double question asks two questions at the same time, for example, 'Do you attend Computing and Science classes?'

Double questions are ambiguous. Does the question mean do you attend Computing and Science classes or do you study either Computing or Science?

### **Offensive Questions**

A question may be considered offensive if the respondent is asked about a sensitive issue.

In some contexts sensitive issues may include age, religion, politics, marital status or relationships.

## **Activity 2**

### **Let's Practise**

Working with a group, design a questionnaire that will be used in class.

Your questionnaire should have at least 10 questions and include a range of question types. When writing the questions, consider the objective of the survey and how you are going to analyse the data (e.g. counts, range, averages).

**Choose a topic from the following:**

Most Popular Leisure Activities	Research activities that do not require technology e.g. reading, dancing, sport, art. Research how much time members of the class spend on leisure activities.
Computing Skills	What computer skills are represented in your class? How confident are your class mates at programming, building websites, graphic design etc. In which areas is there a skills gap? Where do individuals feel they need to improve?
Computer Games	Are computer games popular with everyone in the class? Which types of games are played e.g. racing, shooter, adventure, strategy. Do most people play on or offline/solo or with friends? Which is the most popular console?
Money	Specify an amount of money and ask your classmates how they would spend it. Would they spend it on themselves or other people? Would they give the money away? If so, how would they try and make the world a better place?
New Releases	Which new movies, TV series, music albums or computer games are the class most looking forward to? What new releases are coming out over the next six months? Does anyone intend to reserve/pre-order a copy?

## Guidance notes for teachers

### Activity 1

Ask the students to read the first statements in the student book before discussing the difference between an interview and a questionnaire as a class.

Students should be encouraged to identify that using a scale gives a qualitative answer but does not give the reason behind the answer (qualitative information).

Students should answer that a list produces quantitative data. When all the results are put together, the researcher will be able to identify how many respondents ticked each answer.

The problem of missing data is solved by adding another option/tick box to the list, for example:

Other ☐

In response to the question on ranking, students should be able to identify that the data appears to be qualitative. It is based on a subjective response. However when collated, the rankings can be measured, making the data quantitative.

Discuss the concept of a well written question avoiding ambiguity, testing memory or causing any offence.

### Activity 2

Split the class into small groups (3-4 students suggested).

Each group selects an area to research from the list provided. Monitor and remind students to use a range of question types, referring back to the information in Activity 1.

Each questionnaire should be at least 10 questions long and the students should have a clear idea as to how they are going to use and analyse the data collected.

Each group should have completed a word processed version of the questionnaire by the end of the lesson or start of the next lesson.

### Resources

- Computers with word processing software

### Terminology

- **Subjective** - influenced by personal taste, feelings or opinion