Science Beyond the Boundaries

**Human Enhancement**

**Teacher notes**

**Intended Learning Outcome**

Students will understand what is meant by human enhancement and develop an understanding of the capacity technology has to improve lives as well as an appreciation of what might be possible in the future. There are benefits and risks of enhancing humans, including moral and ethical dilemmas, particularly as technological advancements increasingly focus upon the brain. Decision makers approving access to new technology for medical and non-medical purposes increasingly need to focus upon a wider range of issues to address concerns.

This unit focuses on the connections between the sciences, technology, psychology and philosophy.

***Commentary:***

This topic covers issues around disability which students may have experience of, therefore it is suggested that at the start of the unit students should be alerted to the nature of some of the content and given an opportunity to discuss any concerns.

Human enhancements can be used to improve human functioning, for example a cochlear implant can help deaf people to hear. This unit will focus on technological enhancements, examples of which include bionic arms, robotic exoskeleton, and artificial heart pumps. These examples give functions to those who would otherwise not have them. An area that has received a lot of interest is that concerned with brain-computer interfaces (BCIs), which interact with the brain by recording or stimulating brain signals. With these new technologies comes the need for debate over their use.

This unit prompts students to consider the range of factors and the implications of approving human technological enhancements, with a focus on brain-computer interfaces. Decisions about the use of technology, particularly medical technology, need to be evidence informed and consider a range of factors that look at the effect on the individual as well as wider society.

This is a fast paced area of research and we need to carefully consider the implications for the future of providing new abilities, such as the ability to record or stimulate someone’s thoughts. The Royal Society’s report on Human enhancement and the future of work (2012) has called for an interdisciplinary approach to inform how best to proceed. For those with disabilities human enhancement will offer the chance to acquire lost function but beyond this there are serious moral and ethical questions around how much human functionality should we alter? And who should have access to the technology? And for what purpose? Empirical data are needed to consider the social and ethical impacts on both individuals as well as wider society to inform policy making (Royal Society 2012).

**Outline of Teaching Unit**

At the end of this unit students will take part in a role-play activity in which they will collectively make decisions about whether to approve brain-computer interfaces which are a type of neural interface that can record and send signals to the brain. Students will be able to choose which application of brain-computer interfaces they wish to research and discuss. This activity will help them to identify the non-medical factors which influence decision-making, such as the moral and ethical questions this technology raises.

**Bold sections are classroom-based activities,** those not in bold can be completed either in or out of the classroom.

**Phase 1: Engage students with an introduction to ‘What is human enhancement?’ by watching the two videos. These videos are:** [**https://www.youtube.com/watch?v=veve480q8zg**](https://www.youtube.com/watch?v=veve480q8zg) **and** [**https://www.youtube.com/watch?v=3uV8XZcIBbk**](https://www.youtube.com/watch?v=3uV8XZcIBbk)**.**

**It is worth noting that there is no agreed definition, with some describing it as technology that can be used to improve human form or functioning by going beyond what is necessary to restore or sustain good health (E.g. improving memory) whereas others argue it can be modifying or adding to the traits or abilities a person has, for example a hearing aid for an individual who is deaf.**

**Perhaps a good question to pose is: Is an artificial heart pump an enhancement? (Moore, 2020).**

**Questions to consider** **could include:**

* **Is it simply a repair to achieve normal heart function?**
* **Does the answer to this question depend on who you ask?**
* **Could and should this technology be used to make a normally functioning heart last longer, thereby prolonging life beyond what would be expected?**

**Students should then research examples of human enhancement technology.**

**A pro-forma sheet for collating research information is available to accompany this task (Activity 1\_Researching human enhancements).**

**Introduce tasks for phase 2**

Phase 2: Students work either individually or in small groups to research the process to approve human enhancement technology in their country, the evidence they require and the moral and ethical questions that need to be discussed. There are different sources of evidence, such as research findings, including trial data, financial, legal, and many moral/ethical questions that need to be considered before any technology can be approved.

Links to some different sources of information are given in the slide presentation.

A pro-forma sheet to guide the research into the process of decision making is available to accompany this task (Activity 2\_Decision making process and criteria).

**Phase 3: Students share and explain their findings to build up an understanding of how decisions on the use of technology for human enhancement are made and the evidence required to underpin any decision. As the possibilities move beyond purely medical applications students should discuss the ethical and moral questions that need to be considered to approve technological enhancement. Questions might include:**

* **Who benefits from technological enhancement?**
* **How do you decide if a technology is safe?**
* **Who ought to decide whether another person has a quality of life worth improving?**
* **Who should profit from human enhancement?**
* **If a technological enhancement is not profitable how likely is it to be widely available? And is this fair?**
* **Who pays for the technology?**
* **How is access to the technology decided?**
* **What research and trials have taken place or need to take place?**
* **What are the legal implications of using technology, for example on those who cannot give consent such as children?**

**Introducing phase 4 activity:** Students are asked to research a future brain-computer interface application. They should prepare a 5 minute presentation to give in phase 5 outlining the BCI, its use, associated benefits and risks. The information categories from phase 3 can be used. As well as collecting information, students need also to consider the accuracy and reliability of their source, as well as separating opinion and bias from objective fact.

**Phase 5: Each group should present their BCI and a structured debate should explore the potential future use of BCIs. At the end of the debate participants should vote on whether to approve it or not. There are information sheets to help students discuss the different, legal, medical and ethical issues around BCI use (Activity 3\_Debating). Students can be given different roles or aspects to debate. Questions that you may want to introduce to the debate to help guide the discussion could include:**

* What do you think is the balance of risk and benefit to the user of the device?
* Could users be influenced to use the technology because of the social stigma of disability?
* Does the use of BCI technology perpetuate the idea that disabled people are a burden on society?
* Should a BCI user be held responsible for any unwanted or unintended actions/outputs from a device?
* What might happen if a device is hacked?

**What next?**

Students should outline what they think should be the focus of future human enhancement research? and why?

***Activities for each of the five phases of learning:*** Phases 1, 3 and 5 are classroom based; and *phases 2 and 4* can be completed either in the classroom or independently out of the classroom

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| **Phase** | **Activity** | **Reason for it** | **Activity summary** | **Estimated time** |
| --- | --- | --- | --- | --- |
| 1 | Introduction | Stimulus material, used to build interest and curiosity about human enhancements. To inform discussion on what a human enhancement is.  To consider the impact of technological developments on individuals.  To introduce students to the research task they will need to carry out in phase 2. | Video footage giving a brief overview of the topic.  Pro-forma to use to collate information on different human enhancements. | 30 minutes  (3:43 and 12:46 mins)  25 mins  5 mins |
| 2 | Research | Complete research. | Research how decisions are made, and the evidence that they need to make an informed decision, including considering moral/ethical questions | *1-3 hours* |
| 3 | Sharing research | To collate research findings and decide on the evidence they need to make a decision at the panel meeting in stage 5. | Students share and explain their findings to build up an understanding of how decisions on the use of human enhancement are made and the evidence required to underpin any decisions. They can categorise the data to help inform their phase 4 research and presentation. | 30 m – 1 hr  (Ideally a full hour) |
| 4 | Research and presentation preparation | To research a possible use of brain-computer interfaces and prepare a 5 min presentation to give to the group. | Research the use of brain chips to collect evidence and make a case to present at the meeting in phase 5. | 1-3 hours |
| 5 | Presentation, discussion and decision making | For students to experience presenting evidence to influence decision making. Exploring the evidence and reasons for differences of opinion among panel members to arrive at a decision. | Opportunities to present, discuss and decide what limits or restrictions should be placed on uses of BCIs with the option of taking different debating positions by using activity 3. | 1 hour – (20m per BCI broken down as 5m presentation  followed by  15m discussion |

**Guidance Notes: Pedagogical Approaches**

Students' different life experiences and knowledge of disabilities and medical enhancement may influence their positions on this topic. To facilitate constructive discussion, it is helpful to begin by setting ground rules for these sessions. A school may have particular rules or approaches to teaching potentially controversial or upsetting topics.

The following is a short checklist of things to consider in advance of teaching this unit:

* If it is known (or if you are worried) that particular students, such as those with disabilities may be affected by the content of this unit, it can sometimes be a good idea to let students know what is to be covered in advance and/or to seek advice from experts in your school.
* The classroom should be an open and non-judgemental space. It may be a good idea to allow students the opportunity to leave the room without explanation or time to speak with you confidentially if they wish.
* It should be made clear that everyone is entitled to an opinion but that hurtful or offensive comments will not be tolerated.
* Students should be encouraged to provide deeper explanations of their thinking. This can lead them to challenge what they think and understand why, or why not, they believe what they have said.
* Students should not be pressured into talking about personal experiences.

With a unit like this, it can be hard to keep your personal views to yourself. One of the most important things to do is to create a balance of views with respect and acknowledgement of different arguments.

**AS/A Level Specification Links**

**AQA A-Level Biology Content:**

Organisms respond to changes in their internal and external environments (A-Level-content):

* Receptors in the human retina in sufficient detail to show how differences in sensitivity to light, sensitivity to colour and visual acuity are explained by differences in the optical pigments of rods and cones and the connections rods and cones make in the optic nerve.
* Control of heart rate.
* Nerve impulses and synaptic transmission.
* Skeletal muscles are stimulated to contract by nerves and act as effectors.

Homeostasis is the maintenance of a stable internal environment (A-level only):

* Principles of homeostasis and negative feedback.
* Homeostasis in mammals involves physiological control systems that maintain the internal environment within restricted limits.

**AQA A-Level Law**

The nature of law and the English legal system:

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| --- | --- |

* The distinction between law and morality and the diversity of moral views in a pluralist society.
* The relationship between law and morality and its importance.
* The legal enforcement of moral values.

**AQA A-Level Religious Studies**

* The application of natural moral law, situation ethics and virtue ethics to:

Issues of human life and death:

**AQA A-Level Psychology**

Introductory topics in Psychology:

* The multi-store model of memory: sensory register, short-term memory and long-term memory. Features of each store: coding, capacity and duration.
* Types of long-term memory: episodic, semantic, procedural.
* The working memory model: central executive, phonological loop, visuo-spatial sketchpad and episodic buffer. Features of the model: coding and capacity.

Psychology in context

* Evaluate therapies and treatments including in terms of their appropriateness and effectiveness.
* The divisions of the nervous system: central and peripheral (somatic and autonomic).
* The structure and function of sensory, relay and motor neurons. The process of synaptic transmission, including reference to neurotransmitters, excitation and inhibition.
* The function of the endocrine system: glands and hormones.
* The fight or flight response including the role of adrenaline.
* Quantitative and qualitative data; the distinction between qualitative and quantitative data collection techniques.

**AQA A-Level Philosophy**

Moral philosophy:

* Moral philosophy including fairness and individual liberty/rights.
* The origins of moral principles: reason, emotion/attitudes, or society.

**Key information**

***Neural interfaces*** (Royal Society, 2019a)

Neural interfaces areelectronicdevices that interact with the nervous system, examples include bionic arms and cochlear implants. They work by sending or receiving signals to neurons (nerve cells).

***Brain-computer interfaces*** (Royal Society, 2019b)

BCIs are a type of neural interface that can record or stimulate electrical signals from neurons in the brain, rather than other parts of the body. The use of these has mainly focused upon research into how the brain functions and medical applications such as controlling a prosthetic limb or how to help those with spinal cord injuries. There is significant interest in these technologies and their use beyond medicine has already started. For example, there are companies offering computer game users the ability to control actions via thought using a headset. Being able to stimulate and record brain signals for both medical and non-medical applications presents huge moral and ethical questions.

**Regulation of Brain-computer interfaces** (UK Parliament POST, 2020)

In the UK there is no regulation specific to BCI technology. However, the MDR (Medical Devices Regulation) has fully applied since 2020 which sets out the safety, quality and performance requirements for medical devices marketed in the EU. In the UK the Medicines & Healthcare products Regulatory Agency (MHRA) is responsible for ensuring devices meet the MDR standards. Although devices used in medical applications and those that stimulate brain activity will be regulated by the MDR, those that are non-invasive and simply measure or record brain activity will fall outside of the remit of the MDR. There are calls to develop new regulatory procedures with a stronger emphasis on the ethical and moral questions.

***NICE*** (National Institute for Health and Care Excellence)

In the UK NICE provides guidance to the NHS (National Health Service) on current medical treatments and devices that should be made available to patients, taking a ‘best practice’ approach where both cost and efficacy are considered (Raftery 2001).

***Neuralink*** (https://neuralink.com)

Founded in 2016 by Elon Musk, Neuralink aims to develop brain-computer interfaces that have the potential to help people with conditions such as paralysis. In 2023 it was reported that The FDA (Federal Drug Administration) in the USA had rejected Neuralink’s application to start human trials citing safety concerns (Reuters, 2023). The company has acknowledged implanting BCIs in animals and carrying out tests and it is reported that 1500 animals have died so far following experiments since 2018 (Levy, 2022).

**References**

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