Teacher Guide

Classroom of the Future?
An Ethical Discussion

Grade Level 4-12

Lesson Length
1 class period

Lesson Summary: Students discuss in large and small groups the ethics of using neuroscience technology in the classroom.

Standards Alignment

Next Generation Science Standards

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
- HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Cross cutting Concepts

Influence of Science, Engineering, and Technology on Society and the Natural World

Science is a Human Endeavor

New technologies can have deep impacts on society and the environment, including some that were not anticipated. HS-ESS3-3

Analysis of costs and benefits is a critical aspect of decisions about technology. HS-ESS3-2

Science Addresses Questions About the Natural and Material World

Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. HS-ESS3-2

Objectives – Students will be able to:

- assess how they see technical advances in neuroscience influencing classrooms.
- argue from different points of view regarding the scenarios provided.
- contrast and compare why some of these applications are better than another.

Assessment Options (Evaluate)

Direct students to write:

- a reflection in their notebooks on why a particular scenario is acceptable or not.
- a reasoned critique of a point of view that differs from their own.
- a reasoned critique of their own point of view.

Materials

The set of hypothetical scenarios at the end of this document. Or choose just 1 or 2 scenarios.

Procedures

Engage

Ask students to brainstorm how neuroscience, the study of the brain, might be influencing what goes on in their classroom. Keep track of all ideas on the board. Are all the ideas on the list beneficial? Are any ideas detrimental? How can we evaluate the difference?

Transition to small group discussions by stating that, as they work in a contemporary science, neuroscientists come up with new technologies to study the brain that may subsequently influence education. How should we evaluate these?

> **Note** Some students in the class may be taking Adderall for their own ADHD. Care must be taken to protect their confidentiality. To do so, instruct students to talk in general about 'people with ADHD' or 'people with learning difficulties' and not specific individuals.

Explore

Put students into small groups of 3-6 people, whatever works best for your seating. Give each group a scenario to discuss. The groups can discuss different scenarios or the same scenario.

In the discussions, students should:

- consider how acceptable the neuroscience-based technology is from the point of view of students, teachers, and parents. Does the value of the technology vary based upon these different viewpoints?
- consider the impact of the technology on students who are performing average, below average, or well.
- come to a conclusion regarding whether the technology should be used in schools.
- be ready to report out to the entire class the technology being considered, their conclusion about it, and provide arguments to support their conclusion.

Explain

Have each group report out their discussion conclusions.

- What ideas are common across the class?
- What ideas are specific to different technologies?
- Are new technologies always welcome in every situation?
- What other ways should or could neuroscience influence their education?

Expand

Have students find out more details about the different technologies through searching the internet. To limit search results, add 'education' to the technology names.

- Adderall for ADHD
- Oxytocin
- Transcranial Direct Current Stimulation (tDCS)
- Neuroprostheses (deep brain stimulation, DBS)
- Electroencephalography (EEG)
- Functional Magnetic Resonance Imaging (fMRI)

Give students an overview of different moral principles to use in formulating their arguments. Consider the 6 'moral foundations' principles of Jonathan Haidt. See https://moralfoundations.org/ and the videos therein. Or google 'Jonathan Haidt Moral Foundations' for lots of other views of his works. If you bring in the Moral Foundation ideas after the students have discussed their scenarios, ask what moral principles they are applying.

Scenarios

The scenarios in this lesson were written by Dr. Astrid Schmied and were used in the paper: Schmied A, Varma S, Dubinsky JM: Acceptability of Neuroscientific Interventions in Education. Sci Eng Ethics 2021, 27:52.

ADDERALL®

Adderall has been used in the treatment of attention-deficit hyperactivity disorder (ADHD). It is an approved drug that has been shown to improve concentration. Adderall works by altering the chemical balance of the brain.

Recent research suggests that Adderall might also be useful for improving memory performance in children and adults without ADHD. Thus, in the field of education, Adderall could be directly applied to improve student learning. For example, Adderall might be given to students before lessons, to improve their memory for the material and therefore their performance on subsequent tests.

Note that at the present time, the potential of using Adderall to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using Adderall improves educational outcomes for students who do not have ADHD. So far, the most known common side effects of Adderall are increased heart rate and dizziness. However, its potential long-term effects are unknown.

Oxytocin

Oxytocin has been suggested for the treatment of autism. It is an experimental drug that has the potential to improve sociability. Oxytocin works by altering the chemical balance of the brain.

Recent research suggests that oxytocin might also be useful for increasing trust and generosity in children and adults without autism. Thus, in the field of education, oxytocin could be directly applied to improve student learning. For example, Oxytocin might be given to students to improve their cooperative attachments to other students, increasing their learning from group work.

At the present time, the potential of using oxytocin to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using oxytocin improves educational outcomes for students who do not have autism. So far, the most known common side effects of oxytocin are oversensitivity and irritability. Its potential long-term effects are unknown, however.

Transcranial Direct Current Stimulation (tDCS)

Transcranial Direct Current Stimulation (tDCS) has been suggested for the treatment of depression. It is an experimental technique that has the potential to change brain activity. tDCS works by changing the brain, placing electrodes at the scalp surface that induce electrical currents.

Recent research suggests that tDCS might also be useful for acquiring new vocabulary words in children and adults. Thus, in the field of education, tDCS could be directly applied to improve student learning. For example, tDCS might be applied to students as they learn a foreign language, so that they can improve their memory for new vocabulary words, and ultimately their acquisition of the language.

However, the potential of using tDCS to improve educational outcomes is still unclear at the present time. Additional research is needed to establish whether or not using tDCS improves educational outcomes for students. So far, the most known common side effects of tDCS are a slight itching or tingling on the scalp. However, its potential long-term effects are unknown.

Neuroprostheses

Neuroprostheses (deep brain stimulation) have been used for the treatment of tremors in Parkinson's disease. These are experimental devices that have been shown to change brain activity. A neuroprosthesis works by changing the brain: a surgically implanted device induces electrical currents.

Recent research suggests that a neuroprosthesis might also be useful for directly transferring memories from one person to another. Thus, in the field of education, a neuroprosthesis could be directly applied to improve student learning. For example, a neuroprosthesis might be implanted in students and applied during lessons, to improve their memory for the material and therefore their performance on subsequent tests.

At the present time, however, the potential of using a neuroprosthesis to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using a neuroprosthesis improves educational outcomes for students. So far, the most known common side effects of using a neuroprosthesis are those associated with surgery such as bleeding and infection. Its potential long-term effects are unknown, however.

Electroencephalography (EEG)

Electroencephalography (EEG) has been used to diagnose the cause of seizures in people with epilepsy. EEG is an approved technique that measures electrical activity coming from the brain using electrodes placed on the scalp.

Recent research suggests that EEG might also be useful for predicting the verbal ability of children and adults without epilepsy. Thus, in the field of education, EEG could be indirectly applied to improve student learning. For example, EEG might be used to identify infants who are at-risk for future reading difficulties when they enter school, so that they can benefit from early intervention programs.

However, at the present time, the potential of using EEG to improve educational outcomes is still unclear. Additional research is needed to establish whether or not using EEG improves educational outcomes for students who do not have epilepsy. So far, the most known common side effect of EEG is irritation of the skin where the electrodes are placed. However, its potential long-term effects are unknown.

Functional Magnetic Resonance Imaging (fMRI)

Functional Magnetic Resonance Imaging (fMRI) has been used in the diagnosis of tumors. fMRI is an approved technique that measures brain activity by exposing blood flow in the brain to strong magnetic fields in a scanner.

Recent research suggests that fMRI might also be useful for predicting the mathematical ability of children and adults. Thus, in the field of education, fMRI could be indirectly applied to improve student learning. For example, fMRI might be used to identify kindergarten children who are at-risk for mathematical learning difficulties, so that they can benefit from early intervention programs.

Note that the potential of using fMRI to improve educational outcomes is still unclear at the present time. Additional research is needed at this time to establish whether or not using fMRI improves educational outcomes for students. So far, the most known common side effects of fMRI are anxiety about being confined in the scanner and headaches. Its potential long-term effects are unknown, however.