

Introduction

The following speech, or one similar to it, should be given before students break into groups.

- Most people think that scientists simply say, “Hey, I wonder what would happen if we ran electricity through this part of the brain?”.
- While that could be really fun to see, it’s not science. Can anyone tell me why?
- The goal of science is to create larger theories to explain how the world works. We do this through the “Scientific Method”
- Today we’re going to talk about the scientific method. Who here can describe it to me?
- You generally have the following steps:
 - You ask a question
 - You make a theory
 - The theory makes a prediction
 - You build an experiment that can test the theory
 - You get the result and interpret it
- The coolest thing about science is that it works no matter what; science is a process. Scientists believe that the planets revolve around the sun, not because it’s a scientific fact, but because that’s what the process says is right. If the sun revolved around the earth, then scientists would believe that
- My main point is that the world could have been different, and science would have adapted. Magic could be real and it would not be opposed to science - magic would be studied by scientists.
- Today, we’re going to study magic (**cue green flame**)
- Who has seen Harry Potter, or read the books?
- How do you cast a spell?
- Theories
 - Hand movement is all that matters
 - Wand movement is all that matters
 - Both hand and wand movement are needed to cast a spell
- I want you to focus on the idea of prediction. For science to work, we need to have at least two theories on how something could happen.

How to Make Green Fire

Mix 5 grams boric acid (labeled borax in the grocery/convenience store) and 60 ml methanol (ethanol would work as well, but may have legal issues with being on a school campus). Light with a stick lighter that keeps your hand away from the flame. This must be burned in a metal or glass container. It burns very hot, so be very careful - it should not be put out with water, but rather suffocated using a lid or something that blocks oxygen. **THIS IS NOT SOMETHING A STUDENT SHOULD DO, NOR SHOULD ANY MENTOR WHO IS NOT ENTIRELY CONFIDENT WITH WORKING WITH FLAME!**

Part 1: Magical Ability

- Axiomatic: Some people have magic. Some people don't.
- Wizard description: <https://www.youtube.com/watch?v=vUN7yu7zvz8>
- Research Question: What makes it so that some people are witches and some people are wizards?
- Example Hypotheses
 - (Nurture argument) People's beliefs affect their ability to do magic, and it has nothing to do with the physicality
 - (Nature argument) Wizards/witches are born that way
 - If the nature argument proves true, we can use a lot of the below tests to find out what the difference is

Possible experiments:

- Physical features
 - Gross anatomical differences
 - Extra organs?
 - Neurological differences
 - MRIs, fMRIs (possibly interesting to combine with psychological analysis), post-mortem brain studies
 - Cellular Difference
 - Additional cell types (where would we look?)
 - Additional organelles (which cells would we look at first?)
 - Genetic differences
- Psychological tests
 - Personality differences: Extroversion/Introversion, Conscientiousness, Openness to experience, neuroticism, Agreeableness
 - Do wizards/witches hold different beliefs about reality?
- Genetics/ancestry
 - What can we learn from ancestral studies?
 - Introduce the basic concept of mendelian genetics. Do squibs follow mendelian recessive patterns?
- Note: Squibs (people from wizarding families who can't do magic) are an excellent control for all of these questions.

Part 2: Magic Control System

Axiomatic: Magic initiates on verbal command, and often with the correct sequence of movements of a wand.

Movie Clip: <https://www.youtube.com/watch?v=nAQBzjE-kvI>

Research question: How does the 'magic control system' know when to start a spell?

Semantics based experiments

Example Question: Does the subject have to know what the spell will do?

Hypothesis 1: Subject must know the intent of the spell to cast it

Hypothesis 2: Subject can cast the spell without knowledge of what the spell does

- Give subjects varying degrees of knowledge on the true effects of the spell. For something that creates glowing bats, tell them it 1) Makes glowing bats, 2) Makes bats (the animal), 3) Makes bats (the sports equipment - useful for parsing the semantics of the processing system), 4) Makes a glowing bird, 5) Makes a bird, 6) Makes a glowing cloud, 7) Makes a rock, 8) Makes people forget things, 9) Doesn't do anything, 10) Don't tell them what it does.
- For objects that respond to normal words (e.g., Hermione's Carry all bag), how detailed is their processing system? Assuming there is a gold coin in the bag:
 - Will the bag give you the coin if you say parts of the name (e.g., Gold, Coin)?
 - What if there's a gold bar or a USD quarter in there? Can it distinguish with less information?
 - Will the bag return a gold coin if you ask for a 'moneda de oro' (gold coin in spanish)?
 - If you don't know if there's a gold coin, will it return one when you ask for it?
 - If you ask for 'moneda de oro', but don't know what it means, will the bag return it?

Phoneme based experiments

Example question: How does the 'magic control system' understand words? Does it respond only to latin phonemes? (Use the ma1-4) examples in mandarin.

Hypothesis 1: The magic control system is latin based, and will ignore non-latin phonemes

Hypothesis 2: The magic control system differentiates beyond just latin phonemes

Fishing Expedition

Since we don't know very much at all about this, you could talk about 'fishing expeditions' in science. When you don't have enough information to make a theory, you end up trying a bunch of random things to see if there's a pattern no one has observed yet. Phoneme based research would be a great example.

Possible experiments:

- Change one phoneme in a spell. Vary it from something very similar ('Win-**gal**-dium Leviosa') to something very different ('Win-**Zil**-Dium Leviosa'). How much tolerance does the spell have before it stops working?
- Change intonation of the word. Does 'Wingardium Leviosa' have a different effect than 'Wingardium Leviosa?' (i.e., an upward inflection)? Useful example from Mandarin (ma1-4).
- Does length of the phoneme make a difference? (e.g., 'Win-gaaaaaar-dium Leviosa')
- If it does make a difference, is it length or ratio that makes a difference? (e.g., 'Wiiiiiin-gaaar- diuum Leeev-iiioo-saaa' might work when the above does not)

Part 3: Magic Physics

Axiomatic: If I say 'wingardium leviosa' and point my wand at something, it will start floating.

Research question 1: What are the physics of the floating object?

What are the different ways an object could float? (props would be necessary)

- An invisible plate is beneath the object, lifting it up.
- An invisible hook in the middle of the object, lifting it up
- An invisible force pushes up against gravity for every atom
- Gravity is lowered substantially for the object (if gravity were completely canceled, the object would be rapidly flung away from the earth). Does it still affect other things the same amount with its gravity
- Can you lift a rock, and then add weight to it?
- Does the spell effect force applied from any other direction?

Research Question 2: How does the spell recognize an object?

- If I add a piece of rope to an object that can be lifted, will it lift the rope, or will the rope simply sag on the side? If I tie two objects together with a rope, will it lift both items, or only the one I point to? What if I weld two objects together? What if I use a really stiff wire?
- Can I levitate water? What about jello? A balloon filled with water? A balloon filled with heavy gas? Heavy gas by itself?

Research Question 3: How much force can the spell generate, and can we increase it?

- How would you design an experiment
- Does saying the spell louder help?

Part 2: Mental Magic

Axiomatic: People can change into animals and retain the ability to do complex mental tasks.

Question: How do people think in the magical world, even when their brains are changed so dramatically?

- Does the brain do anything in this universe? For thousands of years, people thought it was used as a radiator, to stop the body from heating up too much. Maybe
- Assuming the brain does something, maybe
- Compare an animagus in cat form to a real cat in an fMRI. Does their brain work the same?
- Maybe the animal brain acts as a receiver to the human brain (stored somewhere else). Is there a delay in the behavior of an animagus cat (i.e., it takes time to propagate a signal)?

- Legilimens: Read someone's mind
- Mind Sieve
- Rememberall
- Animagi: How do their brains continue to work?
- Obliviate: Make someone forget something. What types of things can we make someone forget? (Different modes of memory)

Part 4: Magic physics

- Lumos: Makes a light. What type of light? Color? Wavelength?
- Accio: Recall something
- Wingardium Leviosa: Float something.
- Transfiguration
 - What counts as an object?
 - What can you transfigure things into? How complex can they be?
 - Can you make complex molecules? Medicines? Computer chips?
 - Could you make a nanobot to make other nanobots before it turned back?
- Invisibility cloak: Does it show up on infrared?
- Matter Creation Violation
 - Slug throwing up charm
- Frigideiro: Make things cold

Misc

- Alohomora: Unlocks stuff. What counts as a lock? Can you unlock passwords in a computer? Is there something intelligent driving the determination of the lock picking?
- Avadra Kedavra: What's the method of death?
- Map creating system - how does it understand architecture

- Time turner: Solve any problem
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Wand movement

- How precise does it have to be? How would you measure it? Degrees off would be one method.
- Is it the movement of the hand that matters, or is it the movement of the wand?

- Wand movements
 - How far off can it be?
- Pouches: Test for different abilities of the pouch with respect to language
 - If you gave Hermione completely incorrect information about what a spell was supposed to do, it would stop working.
 - If you didn't tell her at all what the spell was supposed to do, it would stop working.
 - If she knew in very vague terms what the spell was supposed to do, or she was only partially wrong, then the spell would work as originally described in the book, not the way she'd been told
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