SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Scientific Inquiry

Year 7-8

Olivia Bulloch

Mercedes College

Practical Report

Investigating the Effects of EMF on Green Bean Germination, Growth, and General Health

Introduction

Electromagnetic fields (EMF) are invisible waves of energy produced by electronic devices such as Wi-Fi routers, laptops, and mobile phones. While EMF is commonly used for communication and power transmission, researchers have raised concerns about its potential effects on biological organisms, including plants and humans. Studies have shown that prolonged exposure to EMF may influence various cellular processes in plants and animals (Cucurachi et al., 2013). Plants, in particular, may be affected at the germination stage and during early development due to their sensitivity to environmental changes (Roux et al., 2008).

In this experiment, we will investigate how EMF exposure from a Wi-Fi router, a laptop, and a mobile phone influences the germination, growth, and general health of green bean plants on days 4, 7, 10 and 14.

Aim

To determine whether exposure to electromagnetic fields from common household electronic devices affects the germination, growth, and overall health of green bean plants.

Hypothesis

1. Green bean seeds exposed to EMF will have lower germination rates than those not exposed.
2. Green bean plants exposed to EMF will have slower growth in terms of height and root development.
3. The general health of EMF-exposed plants may be negatively affected, showing signs of weaker stems, fewer leaves, or discolouration.

Variables

1. **Independent Variable:** The type of EMF exposure (Wi-Fi router, laptop, mobile phone, or no exposure).
2. **Dependent Variables:**
    - Germination rate (number of seeds that sprout).
    - Growth rate (height of plants and root length).
    - General plant health (leaf colour, stem strength, number of leaves).
3. **Controlled Variables:**
    - Same type of green bean seeds.
    - Same amount of water for all plants.
    - Same light and temperature conditions.
    - Same type of soil and container size.
    - Same distance from the EMF emitting device

Materials

1. 40 green bean seeds (10 per test group)
2. 4 planting trays or pots
3. Potting soil
4. Measuring cup (for watering)
5. Ruler (to measure plant height and root length)
6. Labels (to identify test groups)
7. Wi-Fi router (turned on)
8. Laptop (turned on with Wi-Fi and Bluetooth enabled)
9. Mobile phone (turned on with Wi-Fi, Bluetooth, and mobile data enabled)
10. Notebook (to record daily observations)
11. Camera (optional, for documenting plant health)

Method

Step 1: Preparing the Experiment

1. Label four test groups:
    - Control (No EMF Exposure)
    - Wi-Fi Router Exposure
    - Laptop Exposure
    - Mobile Phone Exposure
2. Fill four planting trays with equal amounts of potting soil.
3. Plant 10 green bean seeds in each tray, spacing them evenly.
4. Using a measuring jug, water each group with the same amount of water daily (100 mL per group).

Step 2: Setting Up the EMF Exposure

5. Control Group: Place the tray in a separate room, away from electronic devices.
6. Wi-Fi Router Group: Place the tray at a distance of 5 cm from an active Wi-Fi router.
7. Laptop Group: Place the tray 5 cm from an open, connected laptop (Wi-Fi and Bluetooth turned on).
8. Mobile Phone Group: Place the tray 5 cm from an active mobile phone (Wi-Fi, Bluetooth, and mobile data turned on).

Step 3: Observing Germination

9. Check all trays daily and on days 4, 7, 10 and 14, record:
    - Number of seeds that have germinated.
    - Any visible differences in sprouting speed between groups.

Step 4: Observing Plant Growth

10. After germination (day 4, 7, 10 and 14), continue monitoring plant growth for two weeks, measuring:
    - Height of each plant (use a ruler).
    - Root length (after carefully removing a few sample plants).
    - Leaf colour and a number of leaves (signs of poor health include yellowing or wilting).
    - Stem strength (observe if plants are weak or bending).

Step 5: Analysing General Health

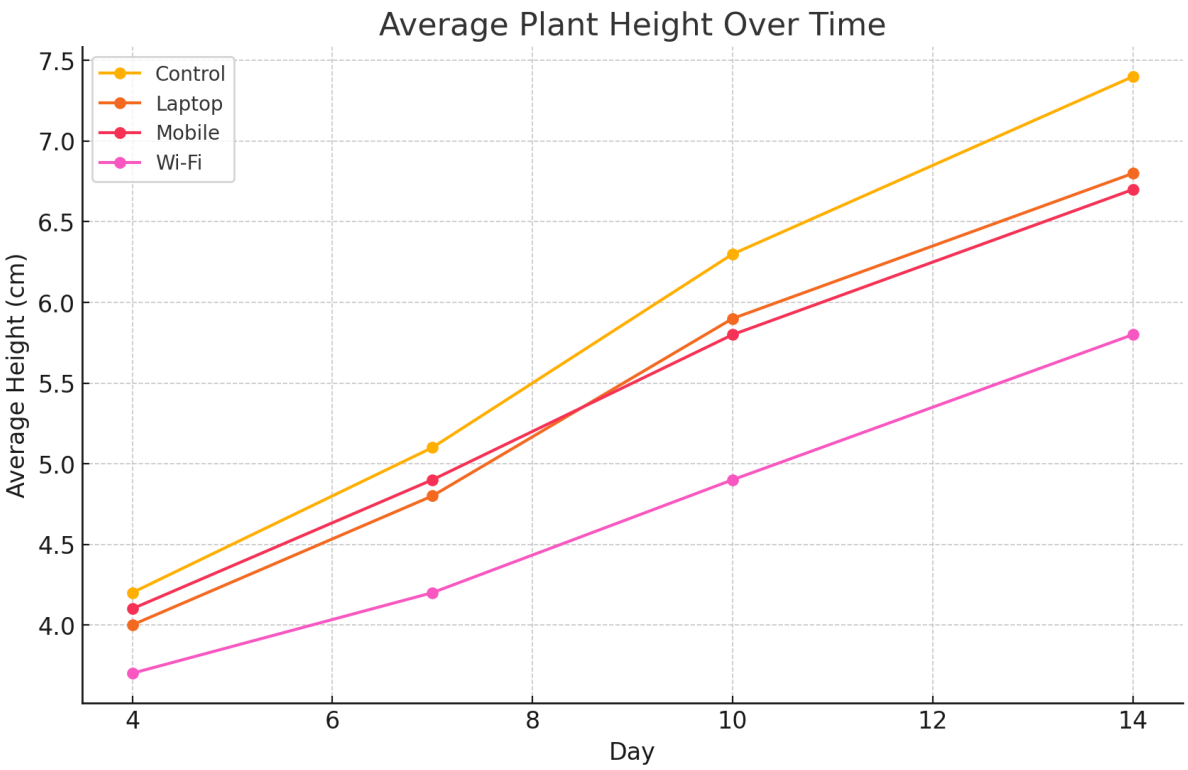
11. At the end of the experiment, compare the overall health of the plants using:
    - Leaf colour (healthy green vs. yellow or pale).
    - Stem thickness (thicker stems suggest stronger plants).
    - Overall appearance (stunted growth, discolouration, or deformities).

Quantitative Results

The Impact of Electromagnetic Fields on Seed Germination, Plant Height and Root Length

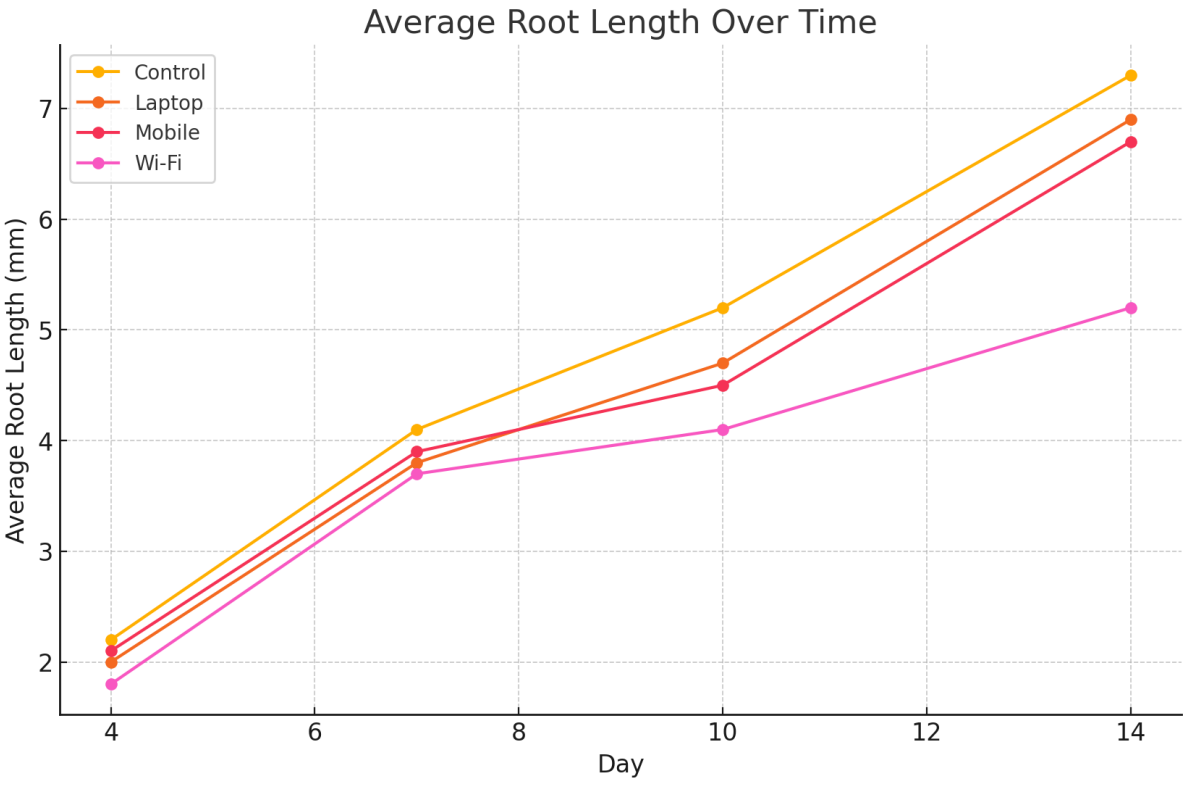
	N.o. of Seeds Germinated (Number)				Avg. Plant Height (cm)				Avg. Root Length (mm)			
Day	Control	Laptop	Mobile	Wi-Fi	Control	Laptop	Mobile	Wi-Fi	Control	Laptop	Mobile	Wi-Fi
4	6	5	5	3	4.2	4	4.1	3.7	2.2	2	2.1	1.8
7	N/A	N/A	N/A	N/A	5,1	4.8	4.9	4.2	4.1	3.8	3.9	3.7
10	N/A	N/A	N/A	N/A	6.3	5.9	5.8	4.9	5.2	4.7	4.5	4.1
14	N/A	N/A	N/A	N/A	7.4	6.8	6.7	5.8	7.3	6.9	6.7	5.2

Table 1: This table shows the Impact of Electromagnetic Fields on Seed Germination, Plant Height and Root Length at Days 4, 7, 10 and 14 for each group (control, laptop, mobile and Wi-Fi)



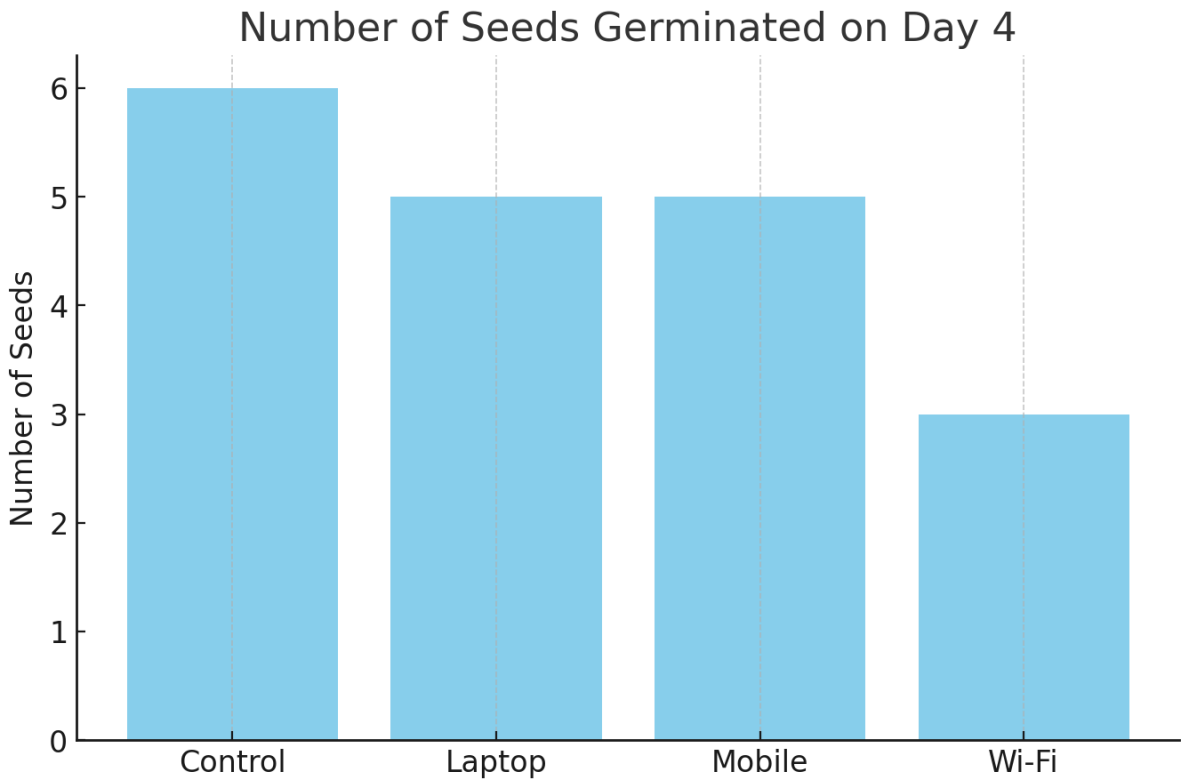
Graph 1: Average Plant Height Over Time

This shows the growth of shoots across all groups (Control, Laptop, Mobile, Wi-Fi) from Day 4 to Day 14.



Graph 2: Average Root Length Over Time.

This graph compares how root growth differed between the groups over the same period.



Graph 3 Number of Seeds Germinated on Day 4

A bar chart showing the number of seeds that successfully germinated in each group at the beginning of the experiment.

Qualitative Results:

Control

Day 4 Day 7 Day 10 Day 14
Laptop

Day 4 Day 7 Day 10 Day 14
Mobile Phone

Day 4 Day 7 Day 10 Day 14
Wi-Fi Router

Day 4 Day 7 Day 10 Day 14

Table 2: This table shows the Impact of Electromagnetic Fields on Seed Germination, Plant Height and Root Length at Days 4, 7, 10 and 14 for each group (control, laptop, mobile and Wi-Fi)

Discussion

1. Comparison of Germination Rates

The control group showed the highest germination on Day 4, with 6 out of 10 seeds sprouting (Table 1, Graph 3). In comparison, the EMF-exposed groups (Laptop, Mobile, and Wi-Fi) showed reduced germination, with only 3–5 seeds germinating in each group. The Wi-Fi group had the lowest germination rate (3 seeds), suggesting it had the strongest inhibitory effect on germination (Table 1, Graph 3). This supports the hypothesis that EMF can reduce seed germination success.

2. Growth Trends

a) Plant Height

Across the observation period (Days 4 to 14), the control group consistently had the tallest plants, reaching an average height of 7.4 cm by Day 14 (Table 1, Graph 1). The Wi-Fi group had the lowest final average height (5.8 cm), followed by the mobile phone group (6.7 cm) and the laptop group (6.8 cm) (Table 1, Graph 1). These findings indicate that EMF exposure slows shoot growth, with the Wi-Fi group again showing the least amount of growth.

b) Root Length

By Day 14, the control group had the longest average root length at 7.3 mm, while the Wi-Fi group was the shortest at 5.2 mm (Table 1, Graph 2). Both the laptop and mobile phone groups also had reduced root lengths (6.9 mm and 6.7 mm, respectively) (Table 1, Graph 2). This trend suggests that root development was negatively affected by EMF, especially from Wi-Fi.

c) Growth Rate

While all groups showed continued growth throughout the experiment, the rate of increase was notably slower in the EMF groups, particularly from Day 10 to Day 14. This might suggest an early halt in growth in the presence of strong EMF exposure, particularly in the Wi-Fi group.

3. General Plant Health

EMF-exposed plants showed visible signs of stress, including:

- Paler or slightly yellow leaves (especially in the Wi-Fi and mobile phone groups) (Table 2).
- Thinner, weaker stems in some EMF groups (Table 2).

These symptoms may be due to EMF-induced stress, which can affect the amount of chlorophyll and vascular development.

4. Comparison Across Devices

The Wi-Fi router consistently had the most negative effects across germination, shoot growth, root growth, and plant health (Table 1 and 2). The mobile phone and laptop had similar, though slightly less severe, effects than the Wi-Fi router (Table 1 and 2). This suggests that different EMF sources may have varying biological impacts, possibly due to differences in frequency and intensity.

5. Errors and Improvements

Systematic errors are errors that occur due to human error or flaws in the experimental design (Lindsey & Jones, 2021). Systematic errors affect the accuracy and, therefore, the validity of the results (Lindsey & Jones, 2021). For this experiment, systematic errors include not measuring the amount of EMF exposure for each group (control, laptop, mobile phone, and Wi-Fi). Therefore, an improvement for this systematic error would be to measure the actual EMF intensity with an EMF meter.

Random errors cause natural variation in the results within a group (control, laptop, mobile and Wi-Fi) and cannot be controlled by the experimenter (Lindsey & Jones, 2021). Random errors affect the precision and, therefore, the reliability of the results (Lindsey & Jones, 2021). A random error could include the daily amount of water, which might be slightly more or less than 100 mL for each group. If plants receive less water, their shoots and roots might not grow as much. Random errors cannot be fixed, but their effects can be minimised. In this case, the effects of this random error can be minimised by increasing the number of seeds per group (control, laptop, mobile, and Wi-Fi), repeating the experiment multiple times and calculating an overall average.

Conclusion

The results of this investigation support the hypothesis that EMF exposure slows down both seed germination and plant growth. Among the tested devices, the Wi-Fi router had the most significant negative impact on green bean plants. These findings suggest that prolonged exposure to EMF, particularly at close range, may interfere with cellular processes essential for plant growth and health (Cucurachi et al., 2013). This experiment provides evidence that EMF can affect living organisms, highlighting the importance of careful consideration when placing devices near plants or other potentially sensitive organisms.

Potential Further Investigations

To build on these findings, future studies could include:

- Test different distances from EMF sources to determine safe zones for plant growth.
- Use a variety of plant species to assess whether EMF effects are universal or species-specific.
- Extend the observation period beyond 14 days, ideally a month, to monitor long-term impacts on flowering, fruiting, or complete plant development.

Word count: 1988

Reference List

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Date : 4/04/25

Introduction :

Name : Olivia Bulloch

Category : Scientific Inquiry

School : Mercedes College

OSA coordinator : Caroline Beekman

Date : 4/04/25

Introduction:

Today, we use many electronic devices like mobile phones, WiFi, and power lines, which create something called electromagnetic fields (EMF's). These invisible energy feilds come from both natural sources (like the Earth's magnetic field) and man-made sources (Like electrical appliances). Scientist are curious about how EMFs affect living thing, including plants. Since plants are an important part of our enviorment and food supply, understanding whether EMFs help or harm their growth is a fascinating question. The experiment that I thought would be interesting to explore is whether a plant, such as beans, when exposed to EMFs, changes how fast it germinates.

What are Electromagnetic Fields?

Electromagnetic fields (EMFs) are invisible forces that come from electric charges. There are two main types:

- Ionizing radiation (like x-rays and gamma rays), which has a lot of energy and can be dangerous to living things

- Non ionizing radiation (like radio waves, microwaves, and the magnetic fields from power lines), which has less energy but is still being studied for its effects on life (WHO, 2007).

Common sources of EMFs include:

- natural sources: The earths magnetic field, lightning, and the sun.

- Man-made sources: Power lines, phones, computer, Wi-Fi routers and microwaves (ICNIRP, 2020). Since artifical EMFs are everwhere, it would be interesting to discover if they impact plants and other organisms.

How do plants respond to their enviorment?

Plants react to many things around them, like sunlight, temperature, and water. They also respond to invisible forces, such as gravity and magnetism, which helps them grow in the right direction. Some scientists believe EMFs might also play a role in how plants develop (Taiz and Zeiger, 2015).

Do EMFs affect seed germination?

Seed germination is when a seed starts to grow into a plant. This stage is crucial because it determines how strong the plant will be. Seeds need the right conditions to sprout and grow. Some studies suggest weak EMFs may help seeds absorb water better and grow faster (Maffei, 2014. However, other studies say EMFs might stress seeds, making them grow slower or not at all (Sharma et al. 2021)

For example one study found that wheat seeds grew faster under certain low EMF conditions, but too much exposure made them weaker (Hajnorouzi et al., 2011). Another study showed that barley seeds grew better when exposed to a static magnetic field (Aladjadjiyan, 2002). These mixed results suggest that different plants might react differently, depending on the strength and type of EMF exposure.

Why does this matter?

My study will specifically explore if bean seeds, when exposed to EMFs, change how fast they germinate. The outcome of my experiment is important because the Australian green bean industry is a major horticutural indastry, that is valued at $104 million. A significant portion of green beans goes to the fresh market, while a smaller portion is exported.

Understanding how EMFs affect plants is important for farmers and scientists. If EMFs help plants grow, they could be used to improve crop production. On the other hand, if EMFs harm plants it could be a problem for farming in areas with lots of electronic devices and power lines (Vian et al., 2016).

Since technology like smart farming and wireless irrigation is becoming more common in agriculture, scientists need to study EMFs effects on plants to ensure crops grow well (Dhawi et al., 2009). This experiment will help explore whether EMFs change plant growth, providing useful information for science and farming.

Green beans are a great way to study EMFs because they react to enviormental changes, and their growth can easily observed. Unlike animals and humans, plants cannot move away from harmful conditions, so their reaction to EMFs are useful in identifying potential risks. The reason why I chose green beans is because:

- They grow quickly - This makes it easier to observe changes over time.

- They share similarities with human cells - Both plants and humans have DNA, proteins and cell structures that react to stress.

- No ethical concerns - studying plants does not raise the same ethical issues as testing on animals or humans.

DO EMFs change a plants health?

Plants need sunlight, water, and nutrients to stay healthy. Scientists have studied whether EMFs change how plants make food (photosynthesis) and how they handle stress. Some studies suggest that EMFs can affect how much chlorophyll (the green pigment in leaves) plants produce, which could impact photosynthesis (Dhawi et al., 2009). Others have found that EMFs cause stress in plants, leading to damage in their cells (Sharma et al., 2021).

For example, one experiment found that wheat plants exposed to EMFs had different enzyme activity, showing that their metabolism was affected (Caliskan, 2016). Another study found that some plants produced extra protective molecules when exposed to EMFs, which might help them survive stress (da Silva and Dobránski, 2016). However, too much EMF exposure can cause damage, reducing plant growth and health.

Date : 5/04/25

How might EMFs affect plants?

Scientists are not exactly sure how EMFs influence plants, but they have a few ideas:

- Changing how nutrients enter plant cells - EMFs might affect how ions (charged atoms) move through plant cell membranes, which could impact nutrient absorption (Belyavskaya 2004).

- Altering genes - some studies suggest that EMFs might turn certain plant genes on or off, changing how they grow and respond to stress (Tkalec et al., 2009).

- Causing stress - EMFs may increase the production of harmful molecules, called reactive Oxygen species (ROS), which can damage plant cells (Sharma et al., 2021).

- Affecting water movement - some researchers think EMFs might change the way water molecules, which could influence how plants absorb and use water (Maffei, 2014).

High - EMF emitting devices:

Many household devices emit electromagnetic fields at different levels. Here are some common sources:

- WiFi routers - constantly emit radiofrequency (RF) waves for internet connectivity.

- Mobile phones - Emit RF radiation, especially when making calls, using data, or connecting to Bluetooth.

- Microwaves - use high-frequency electromagnetic waves to heat food. Some leakage may occur around the door.

- Bluetooth devices - Wireless headphones, speakers, and smartwatches emit low-level EMF when connected.

- Laptops and tablets - Emit EMFs from Wi-Fi, Bluetooth, and internal components, especially when placed on the lap.

Summary:

Scientists are still learning about how EMFs impact plant growth and health. Some studies suggest EMFs can be helpful, while others show they might be harmful. Different plants and exposure levels may lead to different effects, so more research is needed. This experiment will help us understand whether EMFs from High EMFs emitting devices affect seed germination.

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Date: 7/04/25

Practical Design:

Investigating the Effects on Green Bean Germination, Growth and General Health

Introduction:

Electromagnet fields (EMF) are invisible waves of energy produced by electronic devices such as Wi-Fi routers, laptops and mobile phones. while EMF is commonly used for communication and power transmission, researchers have raised concerns about its potential effects on biological organisms, including plants and humans.

In this experiment, we will investigate how EMF exposure from a Wi-Fi router, a laptop, and a mobile phone influences the germination, growth and general health of green bean plants.

Aim:

To determine whether exposure to electromagnetic fields from common household electronics devices affects the germination, growth and overall health of green bean plants.

Hypothesis:

1. Green bean seeds exposed to EMF will have a lower germination rates than those not exposed.

2. Green bean plants exposed to EMF will have slower growth in terms of height and root development.

3. The general health of EMF-exposed plants may be negatively affected, showing signs of weaker stems, fewer leaves or discolouration.

Variables:

1. Independent variable: The type of EMF exposure (Wi-Fi router, laptop, mobile phone, or no exposure).

2. Dependent variables:
   - Germination rate (number of seeds that sprout)
   - Growth rate (height of plants and root length)
   - General plant health (leaf colour, stem streagth number of leaves).

3. Controlled variables:

- same type of green bean seeds
- same amount of water for all plants
- same light and temperature conditions
- same type of soil and container size.
- same distance from the EMF emitting device

Materials:

- 40 green bean seeds (10 per test group)
- 4 planting trays or pots
- Potting soil
- Measuring cup (for watering)
- Ruler (to measure plant height and root length)
- Labels (to identify test groups)
- Wi-Fi router (turned on)
- Laptop (turned on with Wi-Fi and Bluetooth enabled)
- Mobile phone (turned on with Wi-Fi, Bluetooth, and mobile data enabled)
- Notebook (to record daily observations)
- Camera (optional, for documenting plant health)

Method:

Step One: Preparing the Experiment

1. Label your test groups:
   - control (NO EMF exposure)
   - Wi-Fi router exposure
   - Laptop exposure
   - Mobile phone exposure

2. Fill four planting trays with equal amounts of potting soil

3. Plant 10 green bean seeds in each tray, evenly spaced

4. Water each group with the same amount of water daily

Step two: setting up the EMF exposure

5. control group: Place the tray in a seperate room away from electronics devices.

6. Wi-Fi router group: Place the tray next to an active wi-fi router

7. Laptop group: Place the tray next to an open connected laptop (wi-Fi and Bluetooth turned on)

8. Mobile phone group: Place the tray next to an active mobile phone (Wi-Fi, Bluetooth and mobile data turned on)

Step three: Observing germination

9. Check all trays daily and on days 4, 7, 10 and 14 record:
   - number of seeds germinated
   - any visible differences in sprouting speed between groups

Step four: Observing plant growth

10. After germination (day 4, 7, 10 and 14), continue monitoring plant growth for two weeks, measuring:
    - height of each plant (use a ruler).
    - root length (after carefully removing a few sample plants)
    - leaf colour and a number of leaves (signs of poor health include yellowing or wilting).
    - stem strength (observe if plants are weak or bending).

Step 5 : Analysing general health

11. At the end of the experiment, compare the overall health of the plants using:

- leaf colour (healthy green vs yellow or pale)
- leaf count (more leaves indicate better growth).
- stem thickness (thicker stems suggest stronger plants plants)
- overall appearence (stunded growth, discolouration, or deformitics).

Date : 9/06/25

Data collection table :

The impact of electromagnetic fields on seed germination, plant height and root length.

DAY	No. of seed germination (control)	No. of seed germination (wi-Fi)	No of seed germinated (laptop)	No. of seed germinated (phone)	Avg. Plant height (control)	Avg. plant height (Wi-Fi)	Avg. Plant height (laptop)	Avg. Plant height (phone)	Avg root length (control)	Avg root length (wi-Fi)	Avg root length (laptop)	Avg root length (phone)
4												
7												
10												
14												

RISK ASSESSMENT FORM
Models & Inventions

This must be included with your report, log book or entry

NAME: Olivia Bulloch ID: 0370

SCHOOL: Mercedes College

Activity: Give a brief outline of what you are planning to do.

In my experiment I plan to investigate how EMF expose from a laptop, Wi-Fi router and a mobile phone impact the growth, germination and general health of the bean plants.

Are there possible risks? Consider the following:

- Chemical Risks: are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal Risks: are you heating things? Could you be burnt?
- Biological Risks: are you working with micro-organisms such as mould and bacteria?
- Sharps Risks: are you cutting things, and is there a risk of injury from sharp objects?
- Electrical Risks: are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead?
- Radiation Risks: does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Item	Potential Hazard	Risk Level	Control Measures
Green bean seeds	Low risk – potential allergen to sensitive individuals	Low	Wash hands after handling. Avoid ingestion. Notify teacher of any seed allergies.
Planting trays or pots	Sharp edges or breakage if made of hard plastic or ceramic	Low	Handle with care. Do not run or play with trays.
Potting soil	Inhalation of dust, potential pathogens or contaminants	Medium	Wear gloves and avoid inhaling dust. Wash hands after use. Use in a ventilated area.
Measuring cup (for watering)	Slipping hazard if water spills	Low	Wipe up any spills immediately. Fill and pour water over a sink or designated area.
Ruler	Potential for eye injury or poking if misused	Low	Use carefully and appropriately. Do not point or swing rulers at others.

Labels	Choking hazard (if peeled/stuck in mouth), minor skin irritation from adhesives	Very Low	Use as intended. Dispose of label backings properly.
Wi-Fi router (turned on)	Electrical hazard if tampered with	Low	Do not tamper with cables or sockets. Use equipment as instructed.
Laptop (Wi-Fi and Bluetooth on)	Electrical hazard, trip hazard from cables	Low	Use on a stable surface. Keep cords tidy and away from walkways.
Mobile Phone	Risk of breakage, possible tripping hazard from charging cords		Use on a stable surface. Keep cords tidy and away from walkways.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

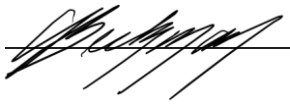
(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name): Oliva Bulloch

SIGNATURE(S): 

☑ **by ticking this box, I state that my / our project adheres to the listed criteria for this Category.**

TEACHER'S NAME: Caroline Beekman SIGNATURE: 

DATE: 10 / 6 / 25