1.2 Doing Scientific Investigation

Introduction to Scientific Investigation

Science is a process of learning about the world through observation, inquiry, formulating and testing hypotheses, gathering and analyzing data, and reporting and evaluating findings. This process is referred as the scientific investigation or scientific method.

1.2 Scientific Method

Activity 1.6

What are the applications of scientific method?

All sciences, including the social sciences, employ variations of what is called the scientific method. Scientific method is the process by which scientists approach their work.

The Steps of the Scientific Method

Based on the type of question being asked, the type of science being applied and the laws that apply to that particular branch of science, you may need to modify the method and alter or remove one or several of the steps.

1. Ask Questions

A scientific investigation typically begins with observations. Observations often lead to questions. This question will include one of the key starters, which are, how, what, when, why, where, who or which. The question you ask should also be measurable and answerable through experimentation. It is often something that can be measured with a numerical result, although behavioral results are part of the scientific method as well.

2. Perform Background Research

With your question formulated, conduct preliminary background research to prepare yourself for the experiment. You can find information through online searches or in your local library, depending on the question you are asking and the nature of the background data. You may also find previous studies and experiments that can help with your process and conclusions.

3. Establish your Hypothesis

Based on the data that were gathered, the researcher formulated a hypothesis. A hypothesis is a tentative explanation for a set of observations. Your hypothesis should also include your

predictions that you can measure through experimentation and research. A hypothesis must be based on scientific knowledge, and it must be logical.

4. **Test your Hypothesis**

   Next, test your hypothesis by conducting an experiment. Your experiment is a way to quantifiably test your predictions and should be able to be repeated by another scientist. Assess your scientific process and make sure that the conditions remain the same throughout all testing measures. If you change any factors in your experiment, keep all others the same to maintain fairness. After you complete the experiment, repeat it a few more times to make sure the results are accurate.

5. **Analyze the Results and Draw a Conclusion**

You can now take your experiment findings and analyze them to determine if they support your hypothesis or not. Drawing a conclusion means determining whether what you believed would happen actually happened. If it did not happen, you can create a new hypothesis and return to step three, then conduct a new experiment to prove your new theory. If what you hypothesized happened during the experimentation phase, the final step is putting together your findings and presenting them to others.

6. **Communicating Results**

The last step in a scientific investigation is communicating what you have learned with others. This is a very important step because it allows others to verify your methods and

results. If other researchers get the same results as yours, the hypothesis becomes stronger. However, if they get different results, they may not support the hypothesis. When scientists share their results, they should describe their methods and point out any possible problems with the investigation. Finally, communicating results can be done in a variety of ways including scientific papers, blogs, news, articles, conferences, etc.

Example1.9: Simple experiment with candle that shows the necessary of air for burning. Consider how the scientific method applies in this simple experiment with air necessary for burning under two different conditions.

1. **Ask Question:** Is air necessary for burning?

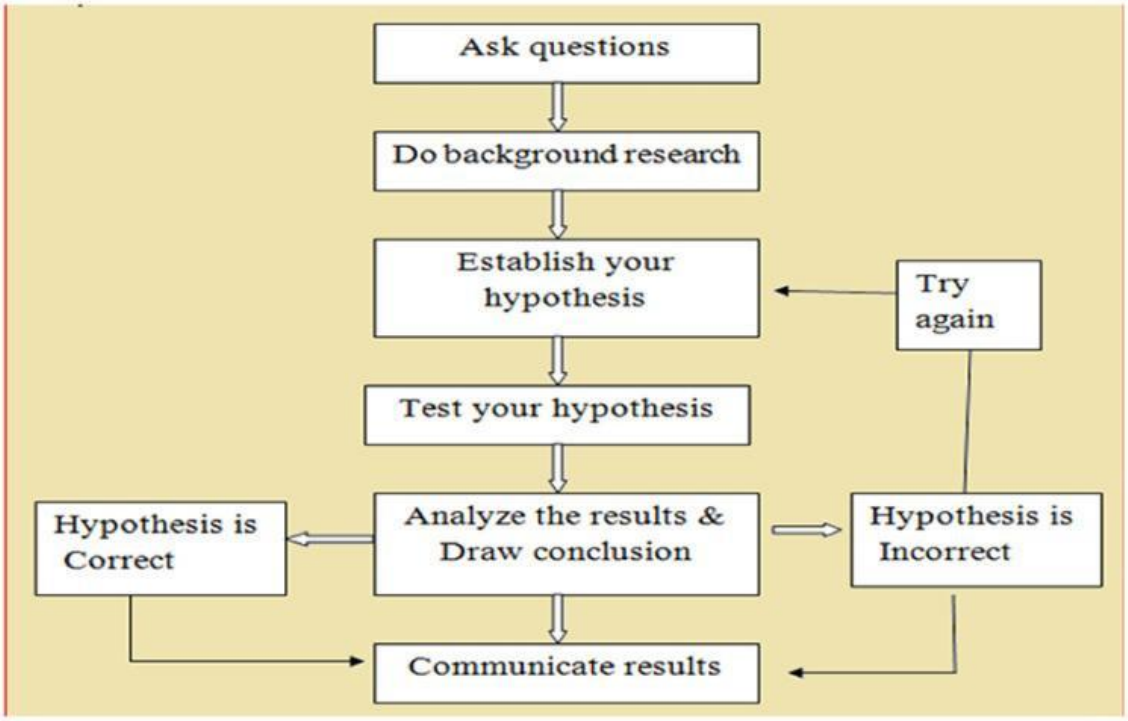
2**. Do back ground Research**: From different literatures "air is necessary for burning."

3. **Formulate Hypothesis:** The null hypothesis is that there wil be no air needs for burning. The alternative hypothesis is that there will be air needs for burning.

4. **Test Hypothesis by Experiment and Collect Data:** Take a candle and fix it on a table. Light the candle. The candle will continue to burn due to continuously available fresh air providing the required oxygen for combustion. Now cover the burning candle by putting an inverted gas jar over it. After a short time, the candle stops burning and gets extinguished.

5. **Analyze the Results and Draw Conclusion:** When the burning candle is covered with gas jar, then the candle takes away the oxygen necessary for burning from the air enclosed in the gas jar. After some time, when all the oxygen of air inside the gas jar is used up, then

the burning candle gets extinguished. This proves that air is necessary for combustion or burning of substances.



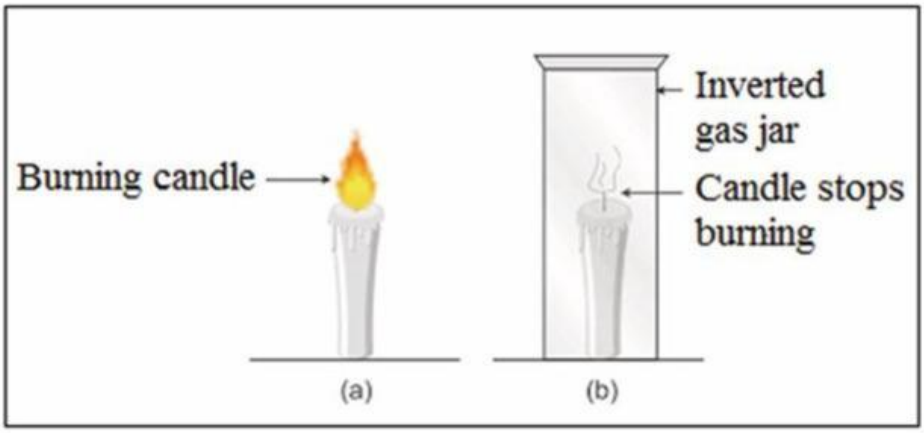


Figure 1.10 a) Burning of candle b) Candle stops burning

6. **Communicate Results**: Report your findings in the form of a written report as an oral presentation. Air is necessary for burning.

MCQs

1. The process of learning about the world through observation, inquiry, hypothesis testing, and communication is called:

   a) Scientific theory
   b) Scientific law
   c) Scientific investigation
   d) Scientific discovery

2. A scientific investigation typically begins with:

   a) Hypothesis
   b) Asking a question
   c) Communicating results
   d) Collecting data

3. A scientific question usually starts with:

   a) How, what, when, why, where, who, or which
   b) Maybe, possibly, sometimes
   c) If, then, else
   d) Always, never, forever

4. A good scientific question should be:

   a) Impossible to measure
   b) Answerable and measurable
   c) Based on personal opinion
   d) Too broad to test

5. Which step comes immediately after asking a question?

   a) Analysing results
   b) Performing background research
   c) Formulating hypothesis
   d) Communicating results

6. The purpose of background research is to:

    a) Prove the hypothesis immediately

    b) Avoid experiments

    c) Gather existing knowledge related to the question

    d) Skip steps in the method

7. A hypothesis is:

    a) A final conclusion

    b) A proven fact

    c) A tentative explanation based on observations

    d) A guess without logic

8. A good hypothesis must be:

    a) Based on scientific knowledge and logical reasoning

    b) Based on personal belief only

    c) Always correct

    d) Impossible to test

9. The step after forming a hypothesis is:

    a) Analysing results

    b) Testing the hypothesis by experiment

    c) Asking another question

    d) Writing a report

10. A good experiment should be:

a) Repeated and fair

b) Done once only

c) Based on guesses

d) Unrepeatable by others

11. In an experiment, keeping all factors the same except one being tested ensures:

a) Accuracy b) Fairness c) Bias d) Failure

12. After the experiment, the next step is:

a) Forming a new hypothesis

b) Analysing results and drawing a conclusion

c) Writing a book

d) Asking unrelated questions

13. Drawing a conclusion means:

a) Guessing results

b) Deciding whether the hypothesis is supported or not

c) Ending the research early

d) Avoiding analysis

14. If the results do not support the hypothesis, you should:

a) Stop the investigation

b) Change data to fit

c) Form a new hypothesis and test again

d) Ignore the results

15. The last step of the scientific method is:

a) Writing hypothesis
b) Asking a question
c) Communicating results
d) Doing research

16. Communicating results is important because:

a) It makes experiments secret
b) It allows others to verify methods and findings
c) It prevents others from repeating experiments
d) It makes research private

17. Scientific results can be communicated through:

a) Conferences and papers
b) Blogs and news articles
c) Oral presentations
d) All of the above

18. If other researchers repeat an experiment and get the same results, the hypothesis becomes:

a) Weaker
b) Stronger
c) Rejected
d) Invalid

19. In the candle experiment, the candle goes out because:

a) The wax finished
b) The wick melted
c) Oxygen in the jar was used up
d) Heat escaped

20. The candle experiment proves that:

a) Heat is not necessary for burning
b) Air is necessary for burning
c) Candles produce oxygen
d) Fire burns without air

21. The **null hypothesis** in the candle experiment was:

a) Air is necessary for burning

b) There is no air needed for burning

c) Oxygen supports combustion

d) Flame goes out without heat

22. The **alternative hypothesis** in the candle experiment was:

a) Burning needs only heat

b) Air is needed for burning

c) Wax alone sustains burning

d) Glass jar produces smoke

23. Which of the following is an example of **observation leading to a question**?

a) Seeing plants bend toward light and asking why

b) Believing something without evidence

c) Assuming results before testing

d) Reading a novel and writing a story

24. Which of the following is **NOT** part of the scientific method?

a) Asking questions

b) Conducting background research

c) Formulating opinions only

d) Testing hypothesis

25. The scientific method is used in:

a) Only physical sciences

b) Only biology

c) All sciences including social sciences

d) Only chemistry