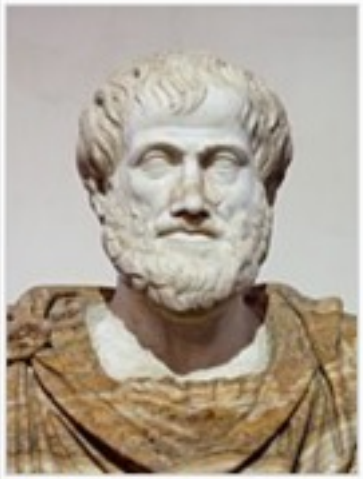
Konsep Pengembangan Sains dan Teknologi

06- Metoda Ilmiah

- The **scientific method** is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.
- To be termed scientific, a method of inquiry is commonly based on empirical or measurable evidence subject to specific principles of reasoning.
- The overall process of the scientific method involves making conjectures (hypotheses), deriving predictions from them as logical consequences,

http://en.wikipedia.org/wiki/Scientific_method

Beberapa pionir metoda ilmiah



Aristotle, 384 BCE – 322 BCE. "As regards his method, Aristotle is recognized as the inventor of scientific method because of his refined analysis of logical implications contained in demonstrative discourse, which goes well beyond natural logic and does not owe anything to the ones who philosophized before him." – Riccardo Pozzo[112]

Roger Bacon (c. 1214 – 1294) is sometimes credited as one of the earliest European advocates of the modern scientific method inspired by the works of Aristotle.[129]

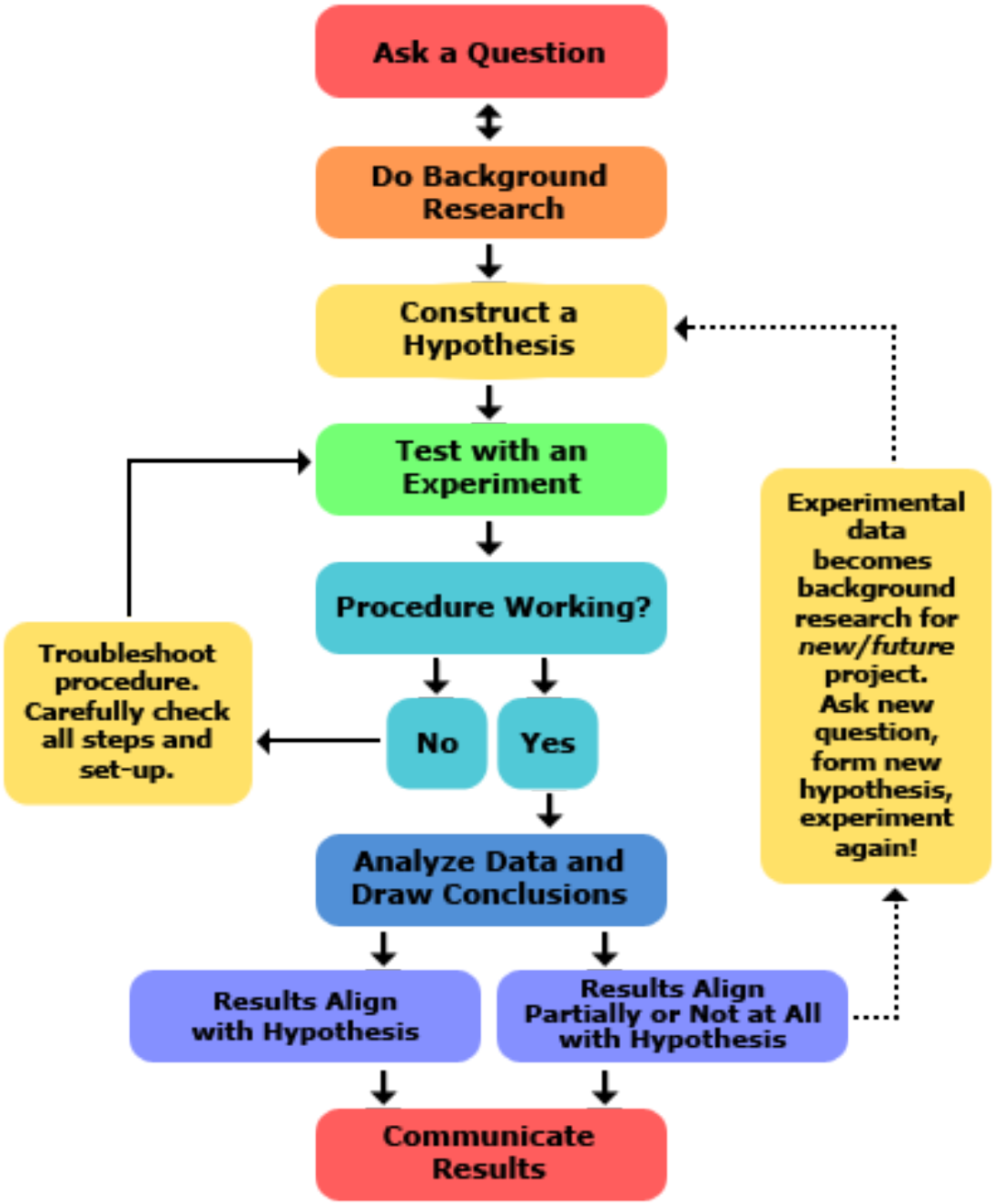
Ibn al-Haytham (Alhazen), 965–1039 Iraq. The Muslim scholar who is considered by some to be the father of modern scientific methodology due to his emphasis on experimental data and reproducibility of its results.[9][10]

Johannes Kepler (1571–1630). "Kepler shows his keen logical sense in detailing the whole process by which he finally arrived at the true orbit. This is the greatest piece of Retroductive reasoning ever performed." – C. S. Peirce, c. 1896, on Kepler's reasoning through explanatory hypotheses[11]

According to Morris Kline,[12] "Modern science owes its present flourishing state to a new scientific method which was fashioned almost entirely by Galileo Galilei" (1564–1642). Dudley Shapere[13] takes a more measured view of Galileo's contribution.

http://en.wikipedia.org/wiki/Scientific_method

Scientific Method



http://www.sciencebuddies.org/engineering-design-process/engineering-design-compare-scientific-method

Example: DNA (1/3)

- **Question**: Previous investigation of DNA had determined its chemical composition (the four nucleotides), the structure of each individual nucleotide, and other properties. It had been identified as the carrier of genetic information by the Avery–MacLeod–McCarty experiment in 1944,but the mechanism of how genetic information was stored in DNA was unclear.

- **Hypothesis**: Linus Pauling, Francis Crick and James D. Watson hypothesized that

http://en.wikipedia.org/wiki/Scientific_method

Example: DNA (2/3)

- **Prediction**: If DNA had a helical structure, its X-ray diffraction pattern would be X-shaped.

  This prediction was determined using the mathematics of the helix transform, which had been derived by Cochran, Crick and Vand (and independently by Stokes). This prediction was a mathematical construct, completely independent from the biological problem at hand.

http://en.wikipedia.org/wiki/Scientific_method

Example: DNA (2/3)

- **Experiment**: Rosalind Franklin crystallized pure DNA and performed X-ray diffraction to produce photo 51. The results showed an X-shape.

Photo 51, showing x-ray diffraction pattern of DNA

- **Analysis**: When Watson saw the detailed diffraction pattern, he immediately recognized it as a helix. He and Crick then produced their model, using this information along with the previously known information about DNA's composition and about molecular

http://en.wikipedia.org/wiki/Scientific_method

Slide #9 - #47 berikut ini didapat dari:

https://docs.google.com/presentation/d/1MorLQtqFQo-1FmnJui578TT-xYj-ONar70FspLdG0QU/embed?slide=id.i354

Steps of the Scientific Method

The Scientific Method involves a series of steps that are used to investigate a natural occurrence.

Scientific Method

Problem/Question
Observation/Research
Formulate a Hypothesis
Experiment
Collect and Analyze Results
Conclusion
Communicate the Results

Steps of the Scientific Method

Steps of the Scientific Method

1. **Problem/Question**: Develop a question or problem that can be solved through experimentation.

Steps of the Scientific Method

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2. **Observation/Research**: Make observations and research your topic of interest.

Steps of the Scientific Method

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3. **Formulate a Hypothesis**: Predict a possible answer to the problem or question.

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Example: If soil temperatures rise, then plant growth will increase.

Steps of the Scientific Method

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4. **Experiment**: Develop and follow a procedure.

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Include a detailed materials list.

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Include a detailed materials list.

The outcome must be measurable (quantifiable).

Steps of the Scientific Method

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5. **Collect and Analyze Results**: Modify the procedure if needed.

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Confirm the results by retesting.

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Confirm the results by retesting.

Include tables, graphs, and photographs.

Steps of the Scientific Method

Steps of the Scientific Method

6. **Conclusion**: Include a statement that accepts or rejects the hypothesis.

Steps of the Scientific Method

6. **Conclusion**: Include a statement that accepts or rejects the hypothesis.

Make recommendations for further study and possible improvements to the procedure.

Steps of the Scientific Method

Steps of the Scientific Method

7. **Communicate the Results**:
Be prepared to present the project to an audience.

Expect questions from the audience.

Let's put our knowledge of the Scientific Method to a realistic example that includes some of the terms you'll be needing to use and understand.

Problem/Question

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John watches his grandmother bake bread. He ask his grandmother what makes the bread rise.

She explains that yeast releases a gas as it feeds on sugar.

Problem/Question

Problem/Question

John wonders if the amount of sugar used in the recipe will affect the size of the bread loaf?

Observation/Research

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John researches the areas of baking and fermentation and tries to come up with a way to test his question.

Observation/Research

John researches the areas of baking and fermentation and tries to come up with a way to test his question.

He keeps all of his information on this topic in a journal.

John talks with his teacher and she gives him a Experimental Design Diagram to help him set up his investigation.

General Layout for an Experimental Design Diagram

Title

The Effect of _____ (Independent Variable)

on _____ (Dependent Variables)

Hypothesis

If _____ (planned change in independent variable),

then _____ (predicted change in dependent variables).

Independent Variable

_____

Levels of Independent Variable and Numbers of Repeated Trials

Level 1 (Control)	Level 2	Level 3	Level 4
Number of trials	Number of trials	Number of trials	Number of trials

Dependent Variable and How Measured

_____

Constants

1.

2.

3.

4.

Formulate a Hypothesis

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After talking with his teacher and conducting further research, he comes up with a hypothesis.

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"If more sugar is added, then the bread will rise higher."

Hypothesis

The hypothesis is an educated guess about the relationship between the independent and dependent variables.

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Note: These variables will be defined in the next few

Independent

The independent, or manipulated variable, is a factor that's intentionally varied by the experimenter.

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John is going to use 25g., 50g., 100g., 250g., 500g. of sugar in his experiment.

Dependent Variable

The dependent, or responding variable, is the factor that may change as a result of changes made in the independent variable.

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The dependent, or responding variable, is the factor that may change as a result of changes made in the independent variable.

In this case, it would be the size of the loaf of bread.

Experiment

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His teacher helps him come up with a procedure and list of needed materials.

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She discusses with John how to determine the control group.

Control Group

In a scientific experiment, the control is the group that serves as the standard of comparison.

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The control group may be a “no treatment" or an “experimenter selected”

Control Group

The control group is exposed to the same conditions as the experimental group, except for the variable being tested.

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All experiments should have a control group.

Control Group

Because his grandmother always used 50g. of sugar in her recipe, John is going to use that amount in his control group.

Constants

Constants

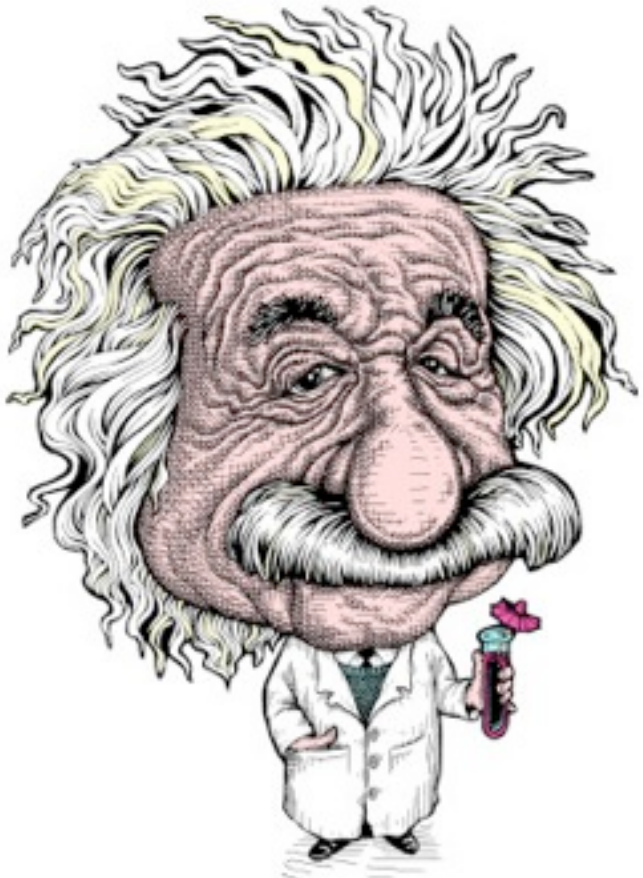
John's teacher reminds him to keep all other factors the same so that any observed changes in the bread can be attributed to the variation in the amount of sugar.

Constants

Constants

The constants in an experiment are all the factors that the experimenter attempts to keep the same.

Can you think of some constants for this experiment?



Constants

Constants

They might include:

Constants

They might include:

Other ingredients to the bread recipe, oven used, rise time, brand of ingredients, cooking time, type of pan used, air temperature and humidity where the bread was rising, oven temperature, age of the yeast…

Experiment

Experiment

John writes out his procedure for his experiment along with a materials list in his journal. He has both of these checked by his teacher where she checks for any safety concerns.

Trials

Trials

Trials refer to replicate groups that are exposed to the same conditions in an experiment.

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John is going to test each sugar variable 3 times.

Collect and Analyze

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John comes up with a table he can use to record his data.

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John gets all his materials together and carries out his

Size of Baked Bread (LxWxH) cm^3

	Size of Bread Loaf (cm^3) Trials			
Amt. of Sugar (g.)	1	2	3	Average Size (cm^3)
25	768	744	761	758
50 Control group	1296	1188	1296	1260
100	1188	1080	1080	1116
250	672	576	588	612
500	432	504	360	432

Collect and Analyze

Collect and Analyze

John examines his data and notices that his control worked the best in this experiment, but not significantly better than 100g. of sugar.

Conclusion

Conclusion

John rejects his hypothesis, but decides to re-test using sugar amounts between 50g. and 100g.

Experiment

Experiment

Once again, John gathers his materials and carries out his experiment.

Experiment

Once again, John gathers his materials and carries out his experiment.

Here are the results.

Size of Baked Bread (LxWxH) cm^3

	Size of Bread Loaf (cm^3) Trials			
Amt. of Sugar (g.)	1	2	3	Average Size (cm^3)
50 Control group	1296	1440	1296	1344
60	1404	1296	1440	1380
70	1638	1638	1560	1612
80	1404	1296	1296	1332
90	1080	1200	972	1084

Conclusion

Conclusion

John finds that 70g. of sugar produces the largest loaf.

His hypothesis is accepted.

Communicate the Results

Communicate the Results

John tells his grandmother about his findings and prepares to present his project in Science class.

Observe your world and come up with a question to answer using the Scientific Method!