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# A Knotty Problem: Tying Student Empowerment to the Curriculum

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Abstract

Participants will explore a hands-on problem solving activity related to science and mathematics. The presenter will relate this activity to the development of a science and mathematics curriculum. This curriculum design should help teachers facilitate the empowerment of students as they actively and continually use the scientific method.

# Curriculum Planning

Assumptions:

- All children are constantly learning.
- All children want answers to their questions.
- All children construct knowledge.
- All children want to be responsible.
- All children want to communicate.
- All children have unique characteristics, interests, abilities, and needs.
- All children should have an equal opportunity to learn, based on their interests, and abilities.
- Children who choose to be involved in scientific inquiry will continue to be involved as adults.
- A multidimensional view of the scientific endeavor is necessary for scientific literate adults

- **A teacher using the learning cycle can create a classroom where a multidimensional view of science can be learned and communicate the above assumptions.**

## Implications of Learning Cycle Instructional Method:

**Student benefits:**

1. Students are empowered.
2. Students are treated as capable.
3. Students are treated as if they can learn.
4. Students are told their ideas are important.
5. Students are told communication of ideas is important.
6. Students are told their peers' ideas are important.
7. Students learn cooperation is powerful.
8. Students conceptualize concepts which are more useful to solve problems.
9. Students conceptualize concepts which are transferred or generalized more easily.
10. Students begin to explore at their personal interest level.
11. Students' exploration is based on their personal understanding.
12. Students continually assess their understanding.
13. Students' communicate more and this communication increases their understanding of science and the associated vocabulary.
14. Students benefit when they communicate more and share ideas, they have to become more logical in order for others to understand.
15. Students learn how to learn.
16. Students learn strategies for experimenting and researching.
17. Students are on task more.
18. Students are more active.
19. Students are in a risk-free environment.
20. Students participate in science as scientists.
21. Students who are empowered to do science will enjoy the benefits of science.

**Teacher benefits:**

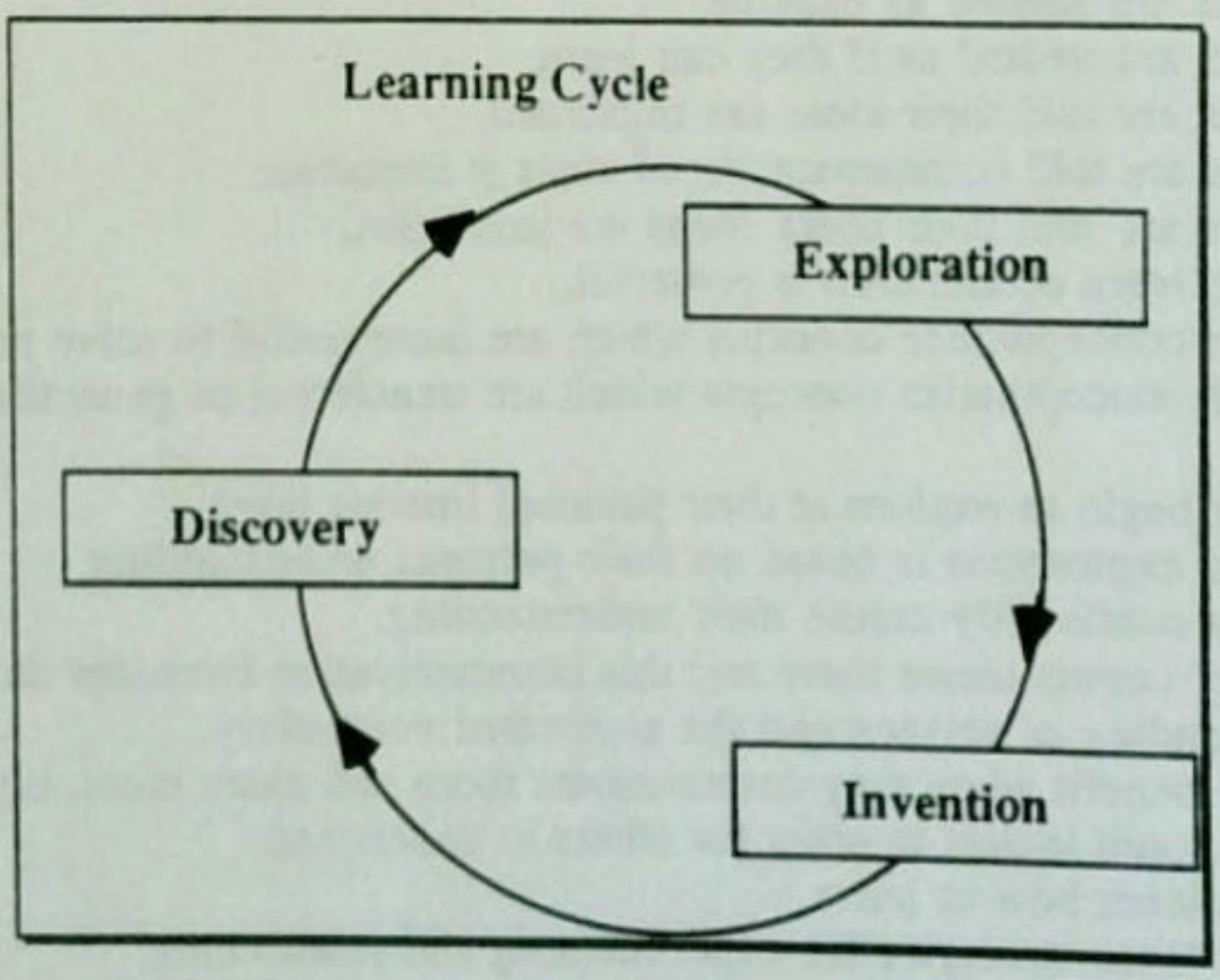
1. Teachers instruct in a more relaxed atmosphere.
2. Teachers enjoy teaching.
3. Teachers have less stress.
4. Teachers become facilitators.
5. Teachers talk less.
6. Teachers ask more questions.
7. Teachers gain greater status as their students learn more.
8. Teachers are happy to hear students and parents tell how students enjoy school.
9. Teachers enjoy seeing students get excited about learning science.
10. Teachers have fewer papers to correct.
11. Teachers collect better information on how students construct knowledge.
12. Teachers continually assess student learning.
13. Teachers assess the transferability of student learning.

## Conclusion:

**The learning cycle must be an integral part of any curriculum design.**

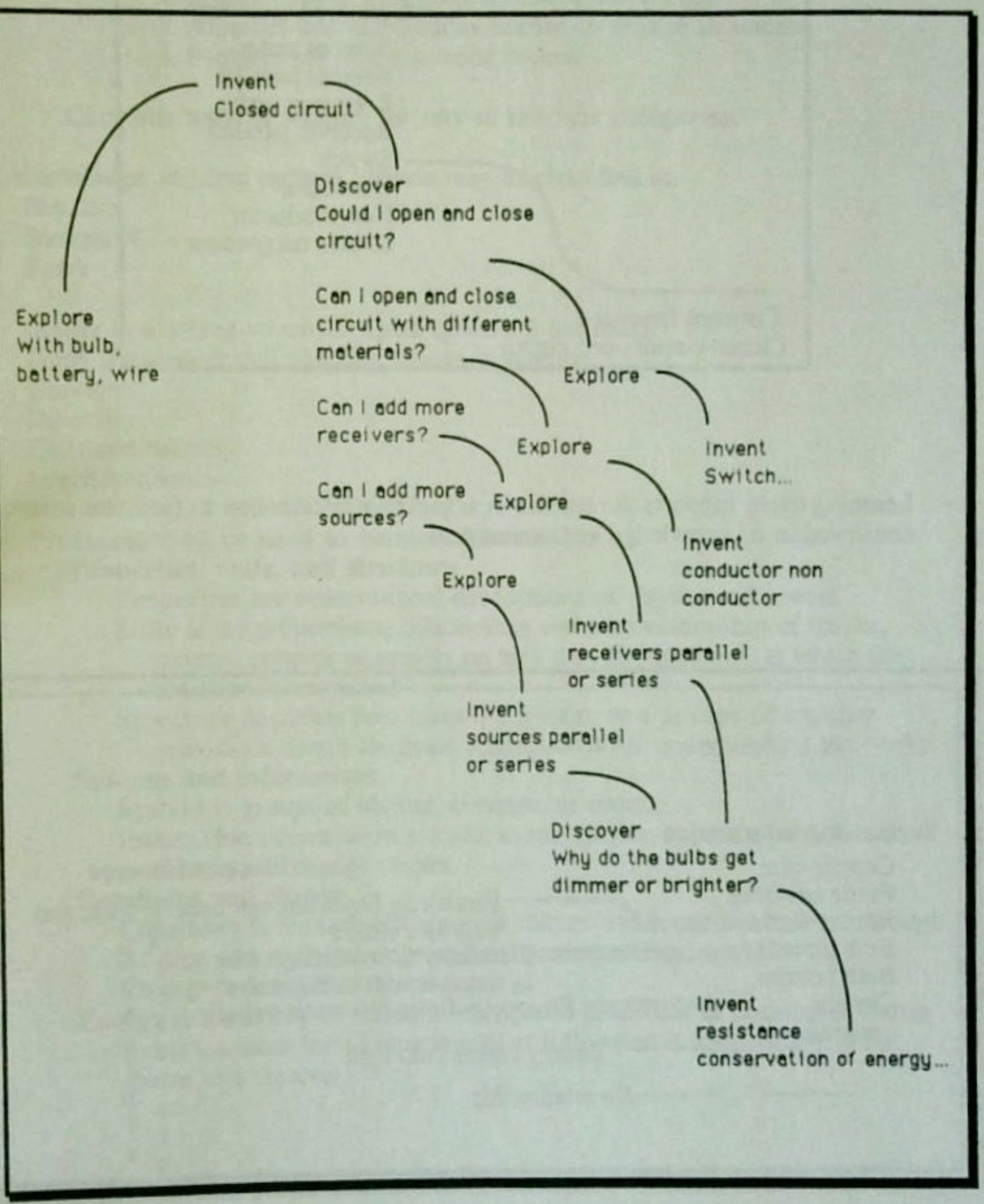
What is the learning cycle?

Learning Cycle



How does the learning cycle help the classroom teacher facilitate instruction?

- The learning cycle supports continual discovery (application of concept), problem solving, real or authentic assessment, and transferability of learning.




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**Summary:**

**Concepts for Discovery**

Sources series
Sources parallel
Receivers series
Receiver parallel
Switch
Conductor
Non conductor
Electro magnetism

**Concept Invented**
Closed circuit open circuit

- Learning cycle supports the teacher in organizing information to facilitate students construction of knowledge and assessment.

**Supporting Information**

Copper wire
Pastic covering
Battery 2 ends
Bulb threads
Bulb bottom
Circular connection
...

**Mastery Concept**

Electricity flows through battery, wire, and bulb as a circuit
Electricity flows through wire as a circuit with bulb attached
Electricity flows like water to bulb
Battery makes bulb light
No relationship

**Alternate Concepts**

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## The scientific endeavor may be classified as

1. Science content knowledge
2. Processes used to acquire scientific knowledge
3. Attitudes and dispositions needed to engage in science
4. Perspectives of the science context

**Concepts may be written for any of the four categories.**

1. **Knowledge** acquired through science may be classified as:
   Physical
   Biological
   Earth

   Matter is anything which occupies space and has mass.
   Force is a push or pull. Motion change in position.
   Universe
   Diversity
   Cells and heredity
   Interdependency

   **Processes may be used to connect knowledge.**
   **Properties, scale, and structure**
   **Properties** are observational descriptions of objects and events.
   **Scale** is the proportional relationship and interrelationship of matter, objects, systems or models on how they fit together. at which the structure is examined.
   **Structure** describes how matter, a system, or a process fit together. provides a means to create relationships for understanding the world.
   **Systems and interactions**
   **System** is groups of objects, energies, or events.
   **Interaction** occurs when a force, event, system, object, approach each other and a change occurs.
   **Constancy and change**
   **Constancy** is the lack of change or change which can be observed through time and analyzed to predict and understand the world.
   **Change** is a result of interactions.
   **Energy** is the ability of matter to change the properties or position of matter and is the basis for all interactions as it flows or is transferred from a source to a receiver.

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## Knowledge categories related to Processes to connect knowledge:

| | Properties, scale, and structure | Systems and interactions | Constancy and change | Energy |
|---|---|---|---|---|
| Matter | | | | |
| Forces and Motion | | | | |
| Universe | | | | |
| Diversity | | | | |
| Cells and Heredity | | | | |
| Interdependency | | | | |

## Sample of processes to connect knowledge

| | Properties, scale, and structure | Systems and interactions | Constancy and change | Energy |
|---|---|---|---|---|
| Physical energy<br>Matter<br>Closed circuit | Properties of battery, bulb, and wire.<br>Properties of electricity.<br>Scale of electricity and bulb/battery/wire system.<br>Structure of battery, bulb, and wire system. | System of battery, bulb, and wire.<br>Interaction of bulb, battery, and wire system. | Constancy of the bulb, battery, and wire system.<br>Change of electricity to light.<br>Change in amount of electricity in the system over time.<br>Change in the amount of light produced in time. | Transfer of energy from electricity to heat to light.<br>Conservation of energy. |
| | | | | |
| Physical<br>Matter<br>Solution<br>Salt water solution | Properties of solids and liquid.<br>Scale of salt as crystal before dissolved and after dissolved in water.<br>Structure of salt as crystal and water as liquid and both as solution. | System of salt and water.<br>System salt water solution and air.<br>Interaction of salt and water.<br>Interaction of salt water solution with air over time. | Constancy of salt over time.<br>Constancy of water over time.<br>Constancy of salt water solution over time.<br>Change of water in air over time<br>Change of salt water solution in air over time. | Flow created by differences between a greater and less concentration.<br>Evaporation and transfer of energy. |
| | | | | |
| Biological<br>Seeds<br>Plants<br>Germination | Properties of seeds.<br>Properties of environmental factors.<br>Scale of seed as a whole, individual parts, and cellular changes.<br>Structure of seed and seed parts. | System of seed.<br>System of plant.<br>System of seed and environmental factors.<br>Interaction of seed and environmental factors. | Constancy of seeds.<br>Constancy of plants.<br>Constancy of environmental factors.<br>Change of seeds.<br>Change of seed to plant (germination).<br>Change of seed and plant and environmental factors. | Flow of materials through seeds.<br>Flow of materials through plants.<br>Energy transfer in plants.<br>Energy transfer for the production of food.<br>Energy transfer for growth. |

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2. **Process Skills to Learn**
   - **Classify**: Group or put in order collections of objects or events based on observable properties.
   - **Communicate**: Convey information through oral and written words, nonverbal signals, diagrams, maps, graphs, and other visual representations.
   - **Connect**: Establish a relationship across topics or with world events.
   - **Hypothesize**: Form a generalized statement which attempts to explain observations or inferences.
   - **Infer**: Interpret or explain given facts or evidence.
   - **Measure**: Use instruments to determine quantitative properties of objects, systems, or interactions being observed.
   - **Model**: A mental representation developed to explain observations and make predictions.
   - **Observe**: Use the five senses to obtain information about objects or events.
   - **Pattern**: Discover repetitive similarities.
   - **Problem Solve**: Use all of the process skills to create a solution which was not apparent to the person seeking a solution.
   - **Interpret Data**: Make inferences, predictions, hypotheses or conclusions from collected data and check for reasonableness of solutions.
   - **Predict**: Make a specific forecast of future observation based on past observation and inference.
   - **Question**: Inquire and search for pertinent information.
   - **Reason**: Form a generalized statement which attempts to explain observations or inferences.
   - **Research**: Collect and interpret information.

3. **Attitudes and dispositions characterized by**
   - **Curiosity** and desire to ask and answer questions to understand at deeper levels.
   - **Open minded** to tolerate ideas and opinions of others and the importance of considering ideas that may seem disquieting or at odds with what they generally believe.
   - **Skeptical** to doubt, question, and reconsider conclusions.
   - **Objectively** make decisions based on facts.
   - **Cooperative** with others for common goals.
   - **Communicate** and share ideas.
   - **Tolerant** of different views.
   - **Persistent** despite obstacles, warnings, or setbacks.
   - **Acceptance** of failure as an occasional part of the scientific endeavor.
   - **Pleasure** in understanding

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4. **Perspective**: This category describes concepts of how science developed and how it has been, is, or could be used by society. This development and use creates a perspective of science.

1. In science, change is predictable, understandable, and controllable.
2. Scientific exploration can lead to everyday discoveries.
3. Scientists challenge ideas to build valid knowledge.
4. Science produces verifiable knowledge that is not absolute and beyond change.
5. Science has roots in history and every part of the world.
6. Scientific views result from a combination or evolutionary changes over a long time and revolutionary changes over a relatively short time.
7. Historically significant events in science have a continuing impact on society.
8. Scientists create physical and conceptual models as guides to understand how systems might work.
9. Decisions must take into account physical, economic, political, social, ecological, aesthetic, and ethical considerations, and make trade-offs among them.
10. Systems are designed to display the qualities of stability, equilibrium, conservation, and symmetry.
11. Knowledge gained from one part of the universe is applicable to other parts.
12. Science is an expression of both human ingenuity and human limitations.
13. Scientific inquiry requires verifiable evidence, testable hypotheses and logical reasoning in the search for unbiased theories.
14. In the past scientific progress was based on accumulated practical knowledge, but today it is more often based on scientific understanding of the principles that underlie how things behave.
15. Social and economic forces determine which technologies will be undertaken and technology in turn has an enormous impact on the nature of human society.

## Resources:


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# Assessment Framework Science

[redacted]

| Concept |
| --- |
| Properties, scale, and structure: |
| Systems and interactions: |
| Constancy and change: |
| Energy: |

| Process Skills of Learning |
| --- |
| Observe |
| Classify |
| Measure |
| Spatial Relationships |
| Communicate |
| Predict |
| Infer |
| Define Operationally |
| Hypothesize |
| Interpret Data |
| Control Variables |
| Experiment |
| Model |
| Create |
| Question |
| Reason |
| Research |
| Connect |
| Pattern |
| Problem Solve |

| Attitudes and dispositions |
| --- |
| Curiosity |
| Open minded |
| Skeptical |
| Objectively |
| Cooperative |
| Communicate |
| Tolerant |
| Persistent |
| Acceptance |
| Pleasure |

| Perspectives |
| --- |
| In science, change is predictable, understandable, and controllable. |
| Scientific exploration can lead to everyday discoveries. |
| Scientists challenge ideas to build valid knowledge. |
| Science produces verifiable knowledge that is not absolute and beyond change. |
| Science has roots in history and every part of the world. |
| Scientific views result from a combination of evolutionary changes over a long time and revolutionary changes over a relatively short time. |
| Historically significant events in science have a continuing impact on society. |
| Scientists create physical and conceptual models as guides to understand how systems might work. |
| Decisions must take into account physical, economic, political, social, ecological, aesthetic, and ethical considerations, and make trade-offs among them. |
| Systems are designed to display the qualities of stability, equilibrium, conservation, and symmetry. |
| Knowledge gained from one part of the universe is applicable to other parts. |
| Science is an expression of both human ingenuity and human limitations. |
| Scientific inquiry requires verifiable evidence, testable hypotheses and logical reasoning in the search for unbiased theories. |
| In the past scientific progress was based on accumulated practical knowledge, but today it is more often based on scientific understanding of the principles that underlie how things behave. |
| Social and economic forces determine which technologies will be undertaken and technology in turn has an enormous impact on the nature of human society. |

## Learning Cycle Plan Framework for Electricity Closed Circuit

**Grade range – sixth - adult**

| Concept |
|---|
| A closed circuit is created with a continuous path through the: (1) top of the battery, (2) bottom of the battery, (3) bottom of the bulb, and (4) threaded side of the bulb.<br>Closed circuit transfers electrical energy. (Generalization) |

| Process Skills of Learning |
|---|
| **Classify** circuits as open or closed. |
| **Communicate** draw diagrams to show the possible transfer of energy. |
| **Connect** closed circuits and the transfer of energy to real life situations. |
| **Hypothesize** how energy is transferred in the circuits. |
| **Infer** how energy is transferred in the circuits. |
| **Measure** |
| **Model** how energy is transferred in the circuits. |
| **Observe** how the objects interact in the system. |
| **Pattern** of closed and open circuits and energy transfer. |
| **Problem Solve** how to close the circuit and transfer energy. |
| **Interpret Data** by collecting observations and inferring how a circuit is created and energy transferred. |
| **Predict** how to close the circuit and how energy transfers. |
| **Question** What are the possible ways to transfer energy in this system? |
| **Reason** infer what is necessary to close the circuit and transfer energy. |
| **Research** information about closed circuits in the system of one bulb, battery, and wire. |

| Attitudes and dispositions |
|---|
| **Curiosity** Desire to use the scientific method to gain information.<br>Curious to acquire information or knowledge in productive ways. |
| **Open minded** Open-minded to ideas and opinions of others and the importance to carefully consider ideas which they may not generally believe. |
| **Skeptical** Refuse to accept ideas without observable evidence. |
| **Objectively** Make decisions based on facts. |
| **Cooperative** Cooperate with others. |
| **Communicate** Communicate ideas in diagrams, written and orally. |
| **Tolerant** Accept other ideas and listen to other students. |
| **Persistent** Persist despite obstacles or setbacks. |
| **Acceptance** Accept failure as part of the scientific method. |
| **Pleasure** Feel positive while constructing knowledge about science. |

## Supporting Information

Battery has electricity
Top has metal bump
Bottom has metal plate
Wire has plastic coating
Metal (copper) inside the wire
Light bulb has a metal tip on the bottom
Light bulb has metal threads on the side
Light bulb has glass on the top
Light bulb has a filament inside
Light bulb lights
Electricity passes through the bulb

## Perspectives

Physical and conceptual models are guides to understand how systems might work.
Scientific exploration can lead to everyday discoveries.
Science, mathematics, and technology are expressions of both human ingenuity and human limitations.
Scientific inquiry requires verifiable evidence, testable hypotheses and logical reasoning in the search for unbiased theories.

## Alternative Concepts

1. Light bulbs and batteries have no interactions.
2. Energy flows from the battery to the light bulb like water from a hose.



3. There must be a circle for the energy to flow.



## Activity

1. Students will construct closed circuits with a light bulb, battery, and wire. (Cognitive synthesis. Affective responding. Psychomotor guided response)
2. Students will draw a model to explain the transfer of energy. (Cognitive synthesis. Affective responding. Psychomotor guided response)

## Assessment

1. Students will use the model they construct to explain why an open circuit is not closed.
2. Students will use the idea of a continuous closed path and four connections to transfer electricity to a motor.

## Materials

Light bulb, battery, and wire for each student. Motors for assessment

## Procedure

### Exploration

1. Give one wire, battery, and light bulb to each student
2. Challenge them to light the bulb.
3. Encourage them to find more ways to light the bulb.
4. If students can not light the bulb have them explain the strategy they are using and try to get them to abandon the strategy and try another. (decenter)

### Invention

1. Have students draw circuits on the board.
2. Have students label the circuits which lit the bulb and circuits which did not light the bulb.
3. Have them find similarities for the circuits that lit the bulb.
4. Have them write an operational definition for the circuit. (A closed circuit for a flashlight bulb, battery, and wire system is created with a continuous path (closed circuit) with the following parts in the path: (1) top of the battery, (2) bottom of the battery, (3) bottom of the bulb, and (4) threaded side of the bulb.)
5. Have students write their discoveries in their learning logs.
6. Do assessment items.

### Discovery

1. Have students make circuits with more objects.
2. Have students make a closed circuit for a circuit tester and test objects to see if they close the circuit (concept of conductor and non conductor).