Inquiry: The Common Theme That Connects Disciplines

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What is Inquiry?

Is it different in different disciplines?

What is Science?

What is Science?

"TO SCIENCE, PILOT OF INDUSTRY, CONQUEROR OF DISEASE, MULTIPLIER OF THE HARVEST, EXPLORER OF THE UNIVERSE, REVEALER OF NATURE'S LAWS, ETERNAL GUIDE TO TRUTH."

- Inscription on the ceiling

of the Great Hall in the National Academy of Science

What is Science?

"SCIENCE IS AN INTERNALLY CONSISTENT SET OF LIES DESIGNED TO EXPLAIN AWAY THE UNIVERSE."

Arthur Boucot

(personal conversation)

What is Science?

- Body of Knowledge

  (Concepts, theories,laws, etc)

- Process/Method

  (Inquiry-derivation of knowledge)

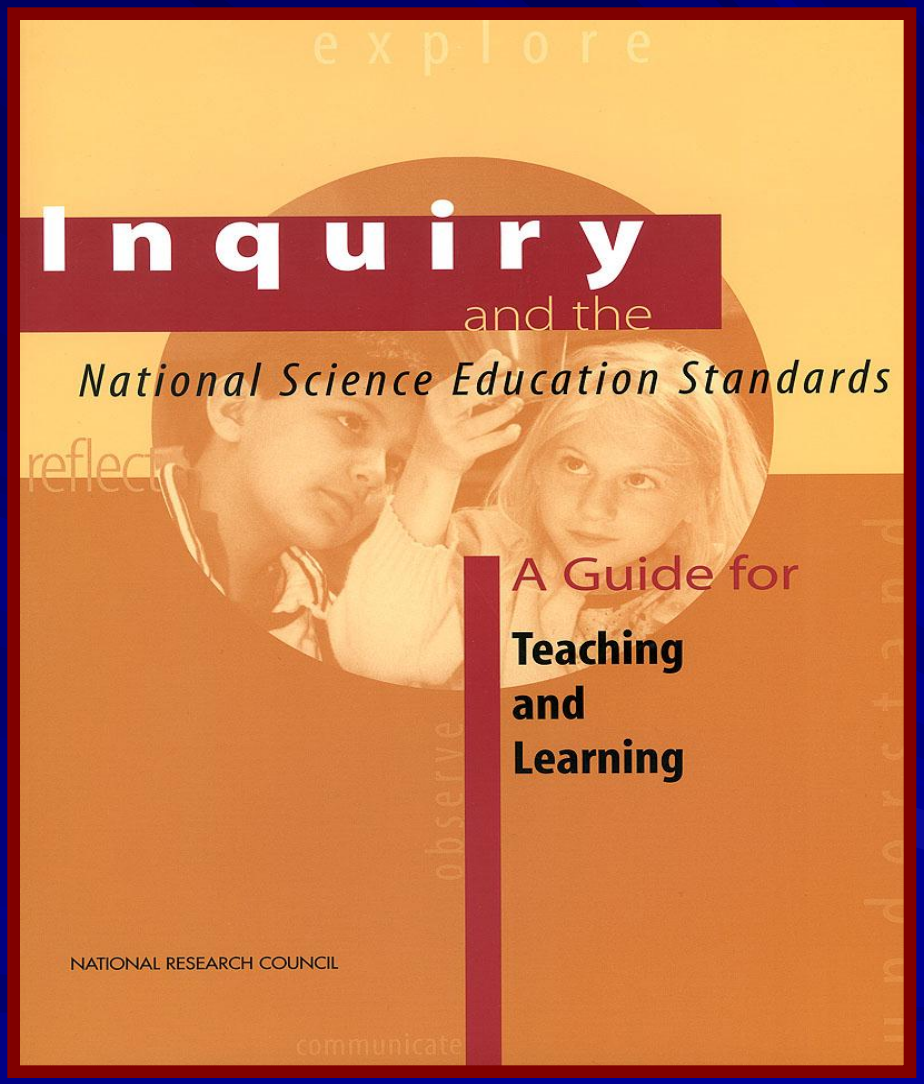
- Nature of Science

  (Characteristics of knowledge)

Scientific Inquiry:

How Is It Defined/Used in Curriculum Reform?

- Teaching approach
- Instructional Outcome
  - Performance
    (What students should be able to do)
  - Knowledge
    (What students should know)


explore
Inquiry
and the
National Science Education Standards
reflect
A Guide for
Teaching
and
Learning
observe
understand
NATIONAL RESEARCH COUNCIL
communicate

Inquiry and NSES *(cont'd)*

Table 2-2. Content Standard for Science as Inquiry: Fundamental Abilities Necessary to Do Scientific Inquiry

Grades K - 4

- Ask a question about objects, organisms, and events in the environment.
- Plan and conduct a simple investigation.
- Employ simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation.
- Communicate investigations and explanations.

Inquiry and NSES *(cont'd)*

Table 2-2. Content Standard for Science as Inquiry: Fundamental Abilities Necessary to Do Scientific Inquiry

Grades 5 - 8

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Inquiry and NSES *(cont'd)*

Table 2-2. Content Standard for Science as Inquiry: Fundamental Abilities Necessary to Do Scientific Inquiry

Grades 9 - 12

- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

Inquiry and NSES *(p.20)*

Table 2-3. Content Standard for Science as Inquiry: Fundamental Understandings About Scientific Inquiry

Grades K - 4

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer.
- Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
- Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
- Scientists review and ask questions about the results of other scientists' work.

Inquiry and NSES *(cont'd)*

Table 2-3. Content Standard for Science as Inquiry: Fundamental Understandings About Scientific Inquiry

Grades 5 - 8

- Different kinds of questions suggest different kinds of scientific investigations.
- Current scientific knowledge and understanding guide scientific investigations.
- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.
- Science advances through legitimate skepticism.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data.

Inquiry and NSES *(cont'd)*

Table 2-3. Content Standard for Science as Inquiry: Fundamental Understandings About Scientific Inquiry

Grades 9 - 12

- Scientists usually inquire how physical, living, or designed systems function.
- Scientists conduct investigations for a wide variety of reasons.
- Scientists rely on technology to enhance the gathering and manipulation of data.
- Mathematics is essential in scientific inquiry.
- Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions a possible modification; and it must be based on historical and current scientific knowledge.
- Results of scientific inquiry - new knowledge and methods- merge from different types of investigations and public communication among scientists.

Important Knowledge **About** Scientific Inquiry

1. **Scientific investigations all begin with a question, but do not necessarily test a hypothesis**

2. **There is no single set and sequence of steps followed in all scientific investigations (i.e., there is no single scientific method)**

3. **Inquiry procedures are guided by the question asked**

4. **All scientists performing the same procedures may not get the same results**

Important Knowledge **About** Scientific Inquiry (Cont'd)

5. **Inquiry procedures can influence the results**

6. **Research conclusions must be consistent with the data collected**

7. **Scientific data are not the same as scientific evidence**

8. **Explanations are developed from a combination of collected data and what is already known**

Forms of Scientific Inquiry

Descriptive: purpose is to describe; may derive important variables and factors that give rise to other types of investigations

Correlational: purpose is to describe relationships among variables

Experimental: purpose is to derive causal relationships among variables

Is there a single "Scientific Method"?

Research on Scientific Inquiry

A few generalizations can be justified from the research related to teachers' and students' understandings about and ability to do scientific inquiry:

1. K-12 students do not typically possess "adequate" conceptions about scientific inquiry

2. K-12 teachers do not typically possess "adequate" conceptions about scientific inquiry

Research on Scientific Inquiry (cont'd)

4. Conceptions about scientific inquiry are best learned through explicit instructional attention as opposed to implicitly through experiences with "doing science."

5. Teachers' conceptions about scientific inquiry are not automatically and necessarily translated into classroom practice

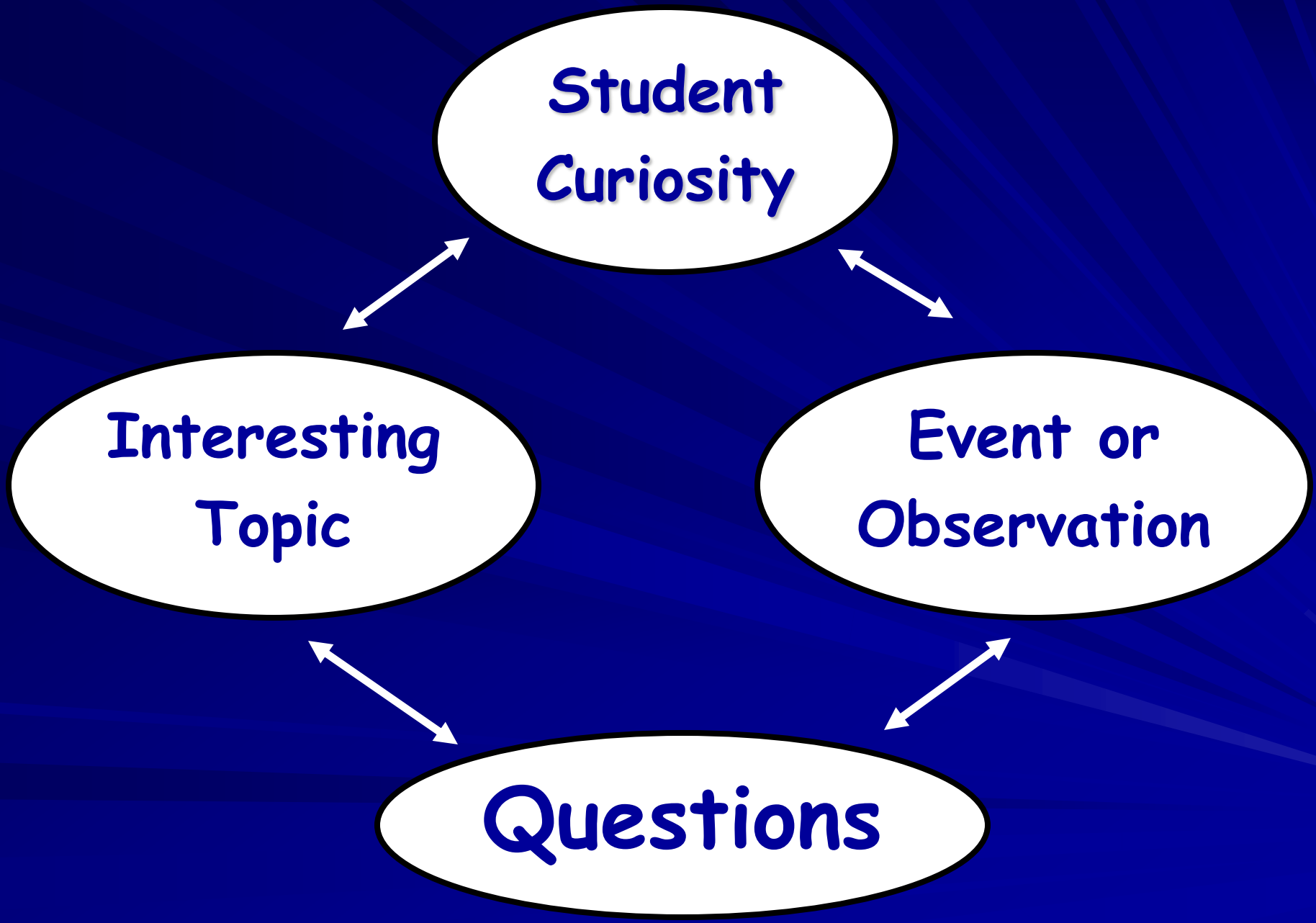
6. Teachers' do not regard understandings about scientific inquiry as an instructional outcome with status equal to that of "traditional" subject matter outcomes.

What Should an Inquiry Oriented Curriculum Include?

- An emphasis on learning concepts.
- An emphasis on higher-level thinking.
- An emphasis on learning about and doing inquiry.
- An emphasis on problem-based learning.
- An emphasis on the use of technology as a learning tool.

Suggested Teaching Strategies:

- Higher Order Questioning
- Inquiry-based Experiences
- Inductive Instruction
- Problem-Based Learning


Student Curiosity
Interesting Topic
Event or Observation
Questions

Candy Investigation

Science Terms

Variable – conditions that change in an experiment

Outliers – data that lies outside the normal range

Control – variables that are not allowed to change during an experiment

Hypothesis – possible answer to the question being investigated

Control Group – a parallel experiment in which the variable being tested is not changed

Math Terms

Range – the difference between the highest and lowest numbers

Outliers – data that lies outside the normal range

Mean – average of all data

Median – middle number in a data set

Mode – the number or piece of data that occurs most often

Compared Content Standards

Content Standard for Science as Inquiry: Fundamental Abilities Necessary to do Scientific Inquiry	Content Standard for the English Language Arts
Grades K - 4	Grades K - 12
Ask a question about objects, organisms, and events in the environment.	Conduct research on issues and interests by generating ideas and questions, and by posing problems.
Plan and conduct a simple investigation.	
Employ simple equipment and tools to gather data and extend the senses.	Gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people).
Use data to construct a reasonable explanation.	
Communicate investigations and explanations.	Communicate their discoveries in ways that suit their purpose and audience.

Continuum of Scientific Inquiry

Level 0

Problem area, methods of solution and "correct " interpretations are given or are immediately obvious from either statements or questions in the students' laboratory manual or textbook.

Level 1

Laboratory manual proposes problems and describes ways and means by which the student can discover relationships he/she does not already know from manuals and texts.

Continuum of Scientific Inquiry *(cont'd)*

Level 2

Problems are provided, but methods as well as solutions are left open.

Level 3

Problems, as well as solutions and methods, are left open. The student is confronted with the "raw" phenomenon.

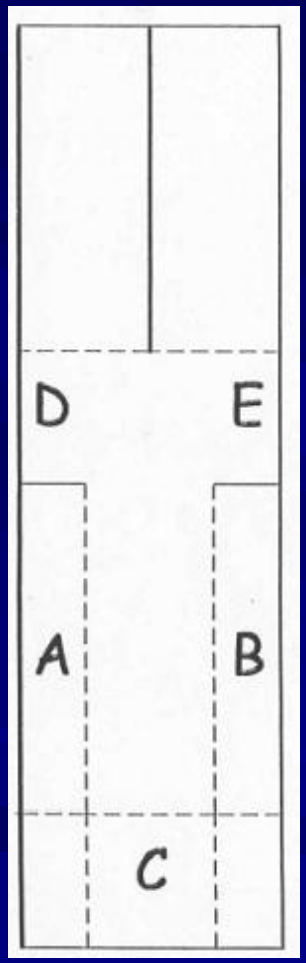
(Adapted from Schwab, 1964; Herron, 1971)

Continuum of Scientific Inquiry

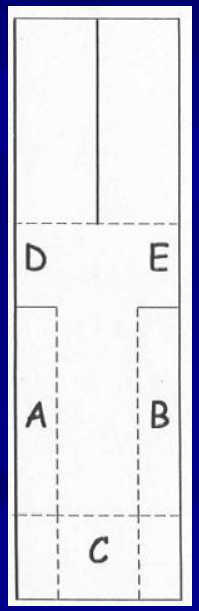
Level	Problem/Question	Procedure	Solution
0	Given	Given	Given
1	Given	Given	?
2	Given	?	?
3	?	?	?

Inquiry Twirly

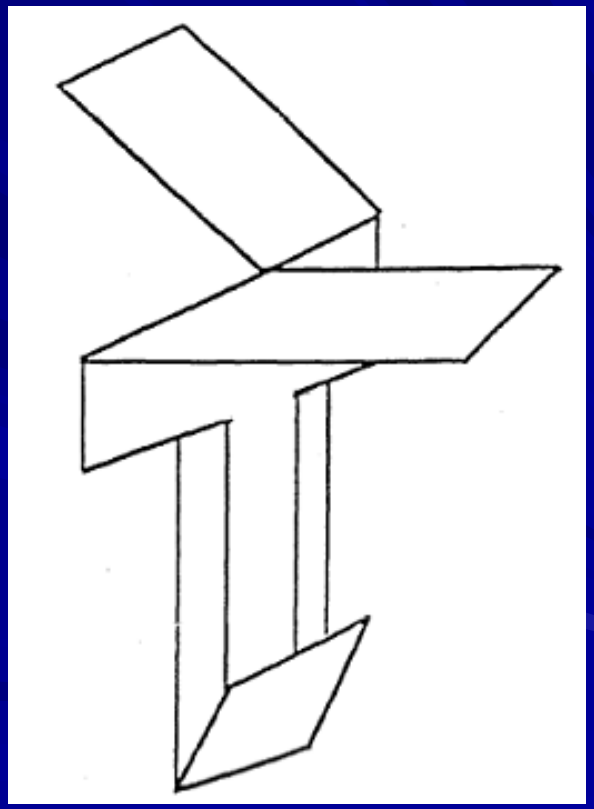
Twirly A Pattern



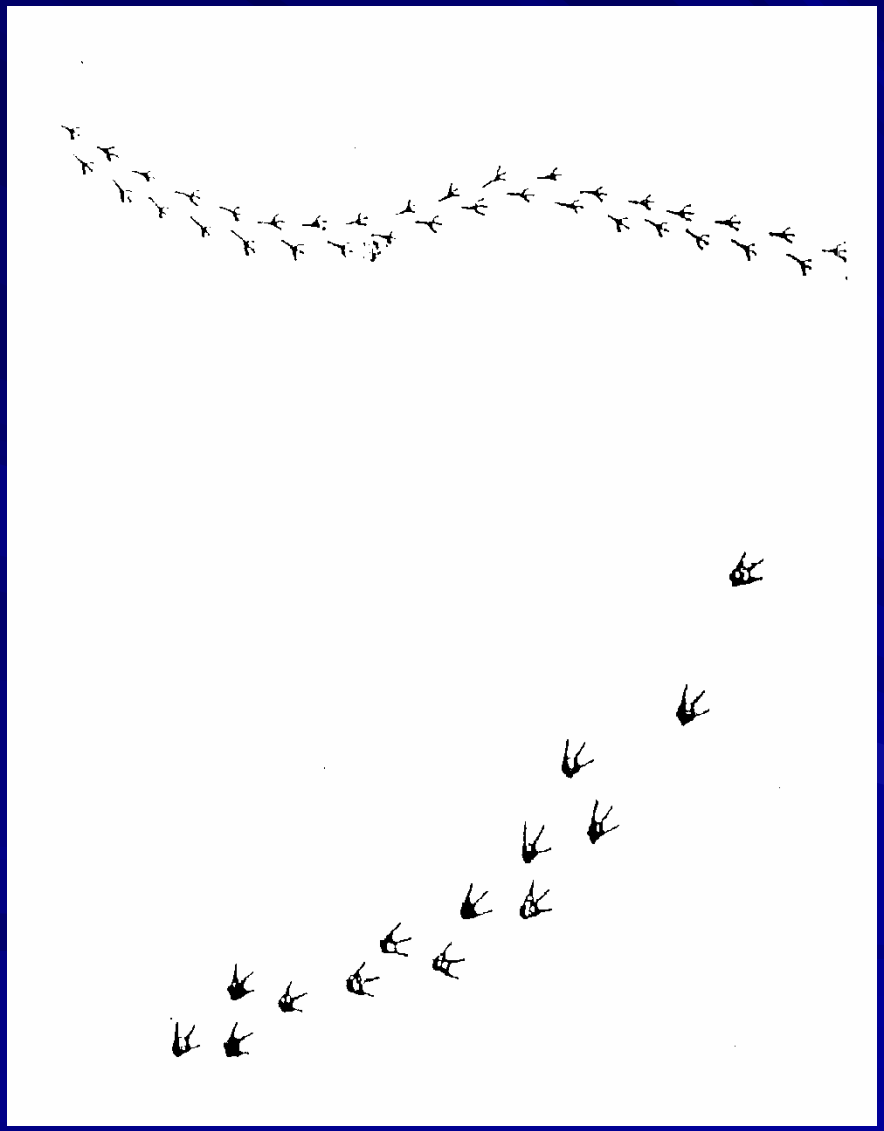
Twirly B Pattern

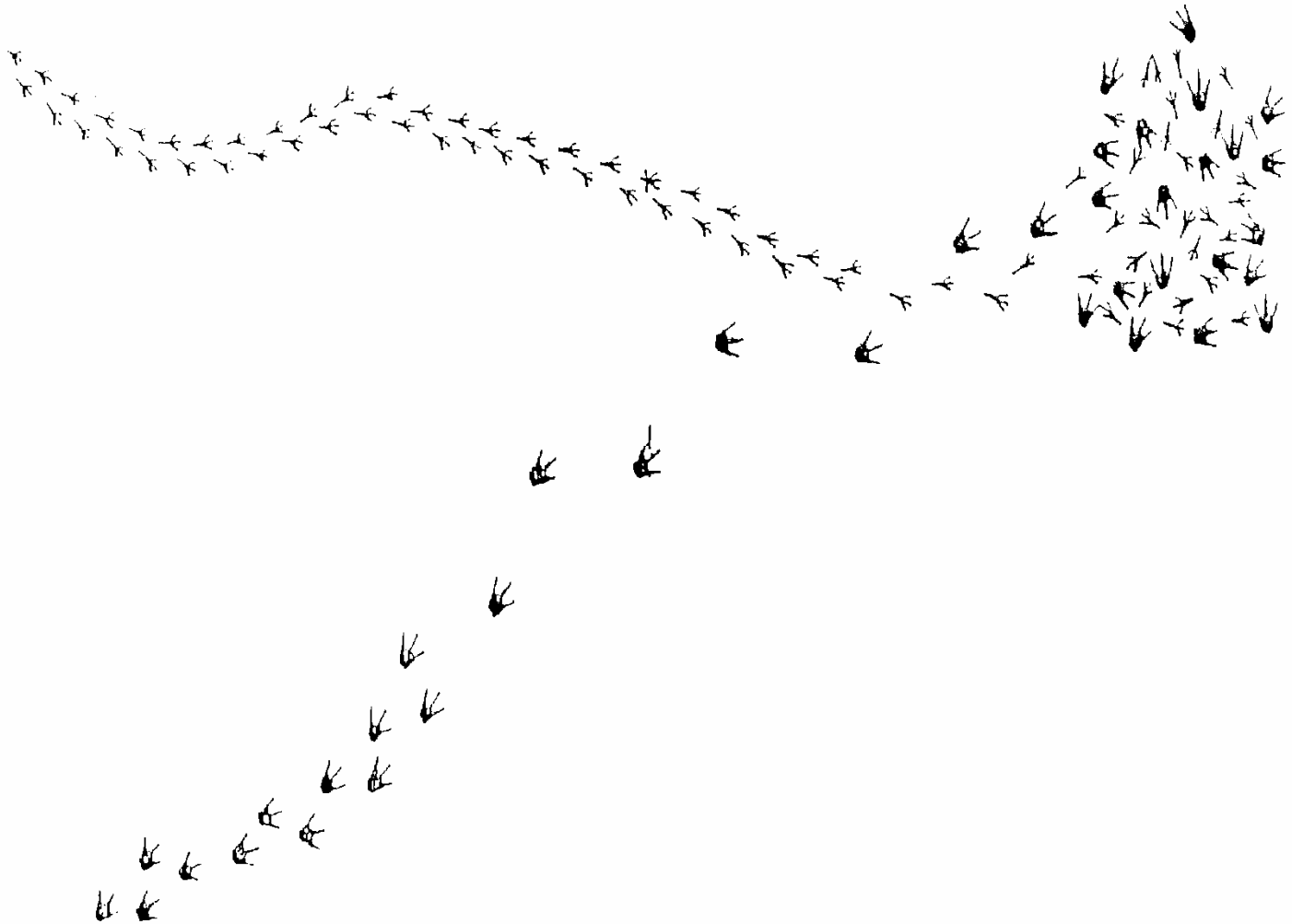


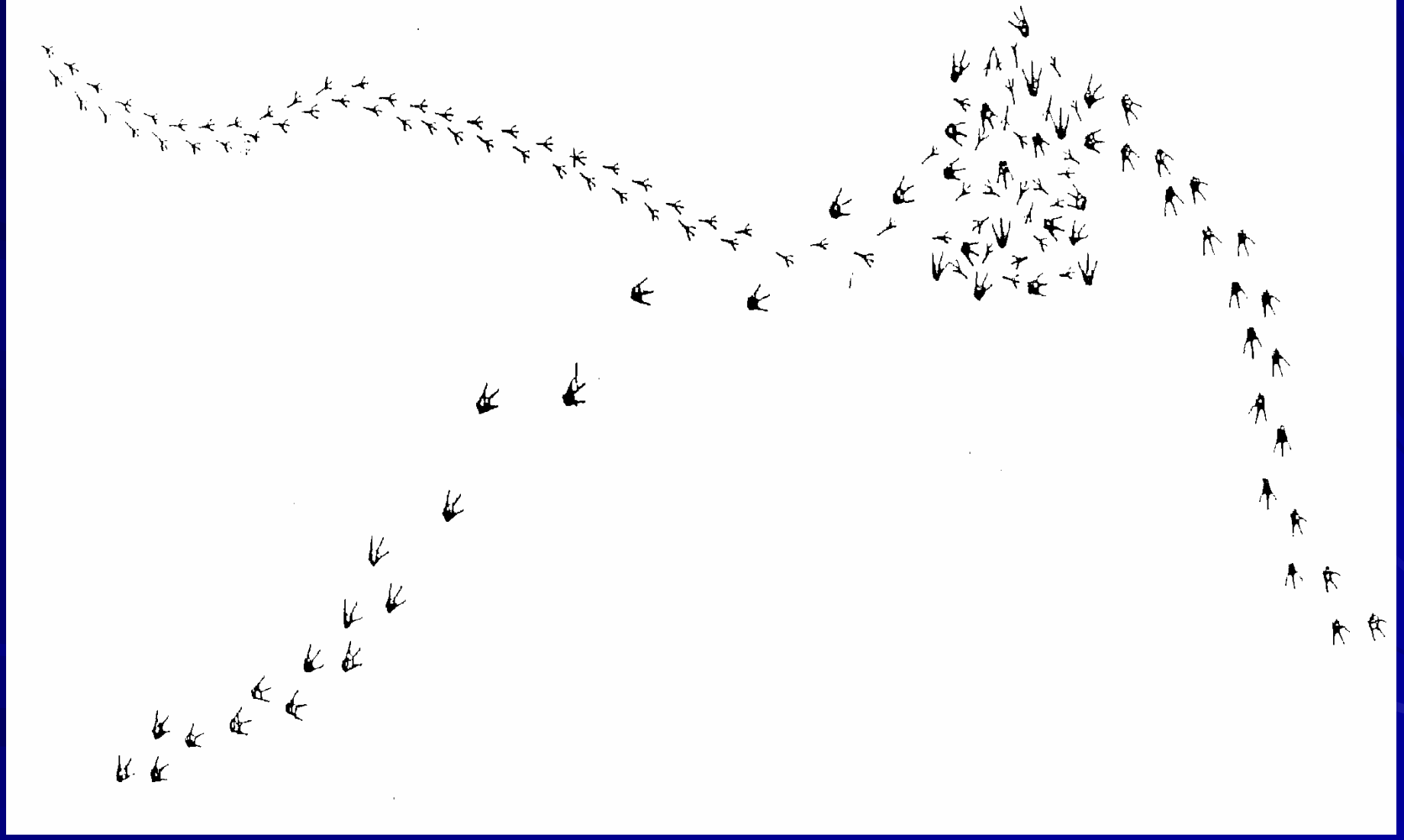
Finished Twirly



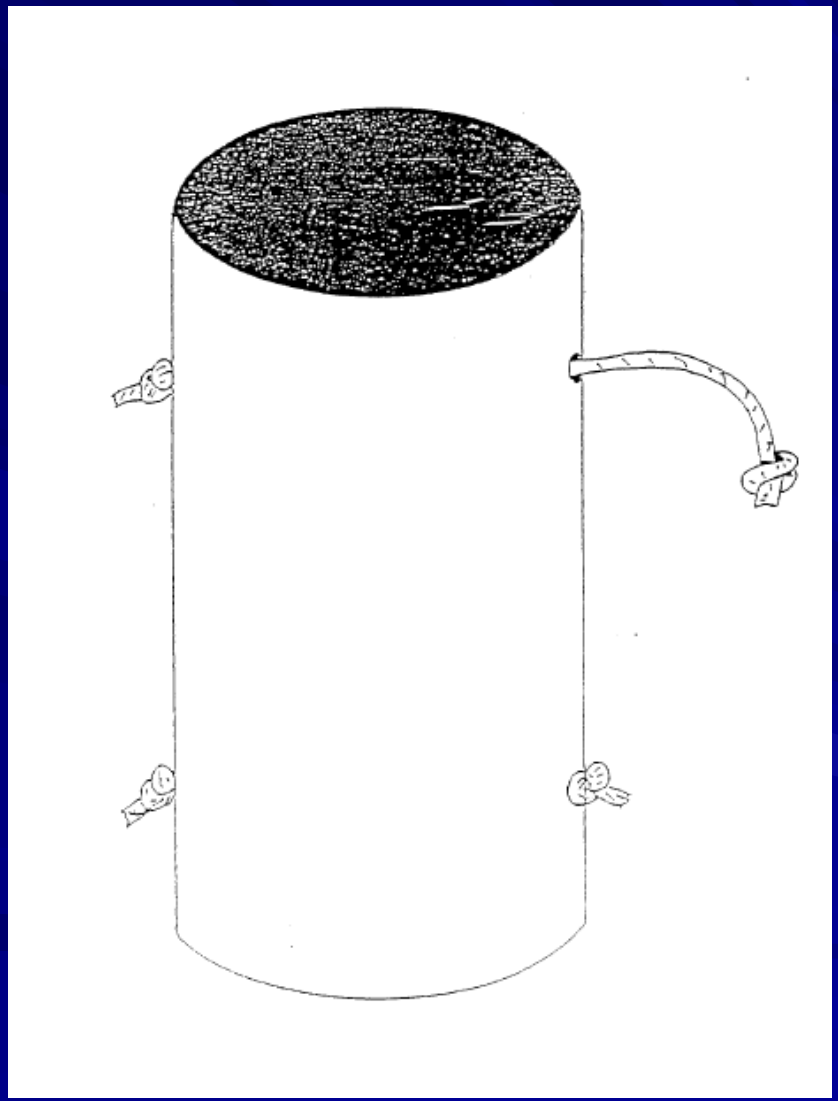
What is Your Inference?

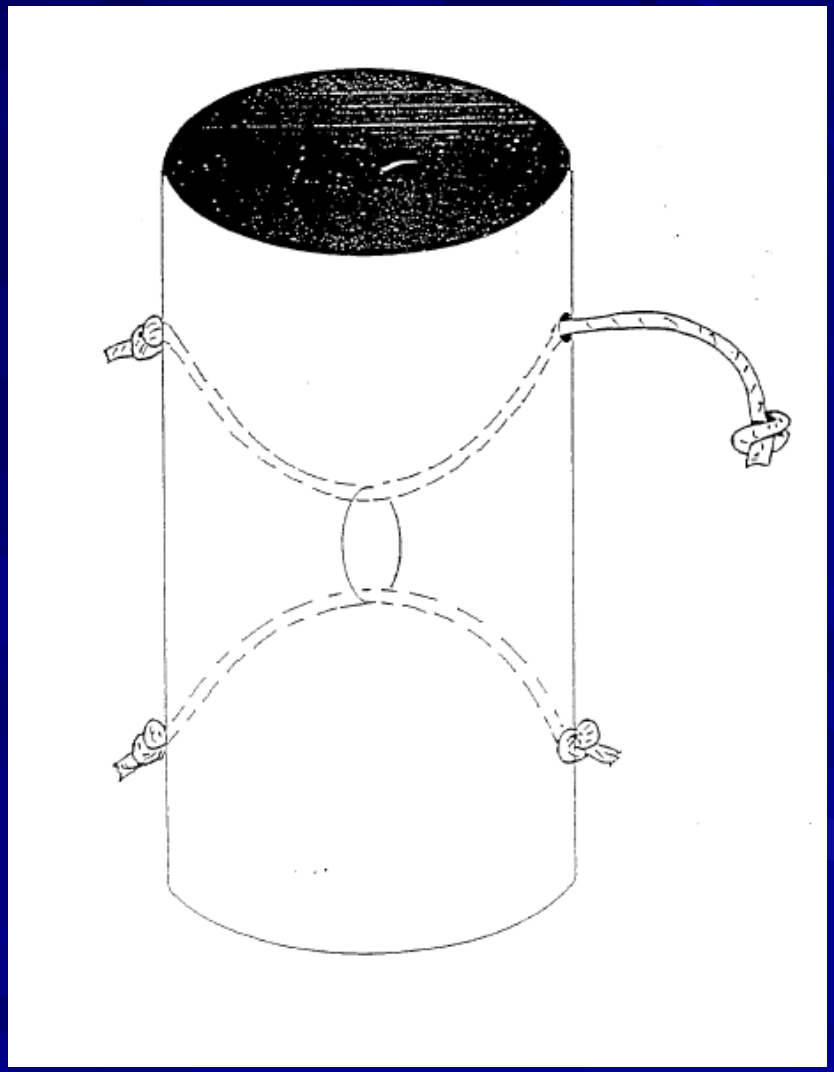






The Universe?





STUDENTS

WON'T LEARN

WHAT

IS NOT TAUGHT


GUINNESS®
GOOD THINGS COME TO THOSE WHO WAIT.
GUINNESS


Fill It Again!!