Creating a Love for Science for Elementary Students through Inquiry-based Learning

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Educators know that science, technology, engineering, and math (STEM) education is crucial for student success in the 21st century. Interest in these areas begins in elementary school and elementary teachers need to be aware of strategies that promote this learning. This paper will explore inquiry-based instructional strategies as a method for generating student interest in science. Inquiry is a process that students use to resolve uncertainty. Grounded in the work of John Dewey, inquiry requires a person to use reflective and critical thinking skills. Inquiry-based instruction is student centered and the teacher is viewed as the facilitator of knowledge and learning. The paper will focus on two inquiry-based instructional strategies: The 5E model and Concept attainment. The 5E model uses five phases: engage, explore, explain, elaborate, and evaluate. The concept attainment model is appropriate for teaching concepts that have a clear set of attributes. This strategy uses a process that allows students to create their own definitions and understanding.

As educators, we know that having an interest and strong background in science, technology, engineering, and math (STEM) education is vital for our students' success. Jobs that require routine skills have decreased, while jobs with non-routine technical skills have dramatically increased within the last decade. Having a solid foundation in STEM areas will enable students to work, live, and meet the demands of the 21st century (State Educational Technology Directors Association [SETDA], 2008).

The US Labor Department projects that most of the fastest growing occupations will require having a significant training in math and science. However, the vast majority of college students are not majoring in these areas. The United States will need at least 400,000 new graduates in the STEM related fields by 2015 to compete in the global economy (SETDA, 2008).

For the purpose of this article, this problem raises the questions: 1) What instructional strategies could be used to create a love for science for elementary school students? 2)What strategies help students connect their backgrounds to scientific ideas?, and 3) What strategies

help students learn in "non-routine" ways? The authors believe inquiry-based strategies are intended to increase student interest in science. This article will discuss inquiry and inquiry-based learning and describe the stages of using two inquiry-based instructional strategies: The 5E strategy and the concept attainment model.

The love and/or interest in science education begins in elementary schools. Younger children tend to be more curious and motivated to learn. The pipeline for increasing the number of people interested in science fields begins in these formative years. Inquiry-based strategies incorporate questioning and active engagement for student learning.

Inquiry can be defined as a process that is used to resolve uncertainty by examining an individual's ideas and beliefs. Grounded in the work of John Dewey, inquiry requires a person to use reflective and critical thinking skills. Inquiry uses skills that are active, persistent, and based on a person's knowledge. Inquiry is a vibrant approach to learning that involves exploration, questioning, making discoveries, and testing discoveries to search for new understanding (Lemlech, 2010).

In contrast, traditional science instruction can be less vibrant and rarely involves student exploration, questioning, and making discoveries. This instruction is teacher centered and is limited to school based resources. There is a focus on "one" correct answer and mastering of content knowledge. Less importance is placed on nurturing attitudes and developing scientific skills. Traditional science instruction is centered on what is known and does not use technology to enhance learning.

Conversely, inquiry-based instruction is student centered and the teacher is viewed as the facilitator of knowledge and learning. Technology is also used to connect students to local and world resources. In addition to understanding content, assessment is focused on learning a

progression of skills. This instruction invokes thinking and questioning and emphasis how did we "come to know" this answer (Lemlech, 2010).

Inquiry is the basic building block for science education for elementary schools (Bybee, 2011). Inquiry for elementary students involves getting them to ask scientifically-based questions about objects, living things, and their natural world. It features having students make a connection between observations and collecting evidence. Observations are also used to help students develop their own questions. Inquiry for elementary students helps them evaluate their responses and allows them to clearly communicate and support their answers with evidence (Bybee, 2011).

The National Science Teachers Association (NSTA) also supports curriculum incorporating inquiry for all elementary school students. The National Science Education Standards state students who engage in science inquiry demonstrate an ability to describe objects, ask questions, communicate ideas to others, and construct explanations. Other inquiry behaviors include identifying assumptions, considering alternative explanations, and using critical and logical thinking (National Science Teachers Association, 2002).

Inquiry-Based Instructional Strategies

The Five E instructional model progresses through five phases that begin with the letter "E": engage, explore, explain, elaborate, and evaluate. In the first phase, **engage**, the teacher's role is to motivate and raise student interest in the subject. This can be done through an activity or experience that allows students to connect current and past experiences. The teacher could also ask an intriguing question, present a problem, or show a discrepant event. This stage is critical because it lays the groundwork for subsequent steps (Bybee et al., 2006). Students are encouraged to ask a variety of questions which include:

Why did this happen?

What can I find out about this?

How can this problem be solved?

Activities that help students engage and stimulate their thinking include:

- Teacher Demonstration
- Free Writing
- Brainstorming
- Using a KWL chart (Know already-Want to know-Want to learn)
- Analyzing a graphic organizer
- A short reading from a journal or piece of literature
- Watching a short video

After students are engaged, they move to the **explore** phase of this strategy. The teacher's role is to facilitate or coach students by involving students in activities which help them think, problem solve, or investigate. The teacher asks questions, observes, and listens to student interactions. The activities help students develop an understanding of a science concept, skill, or process. These experiences should be concrete and meaningful because they will provide a foundation for formally introducing the science objective. This phase can also have students form hypotheses, test their predictions, record observations, and discuss alternatives with each other (Bybee et al., 2006).

Activities that help student explore include:

- Performing an investigation
- Reading resources to collect information
- Problem solving
- Constructing a model

The teacher's task in the **explain** stage is to formally present the scientific concept, process, or skill. His or her explanation is based on the activities presented in the engagement and exploration experiences. This explanation connects students' prior knowledge, observations,

and findings from the exploration activity. This will help students to comprehend the teacher's explanation and help them answer their own questions

Examples of teacher explanation activities include:

- Structured Questioning
- Reading and discussion
- Student analysis and explanation
- Supporting ideas with evidence
- Thinking skill activities: compare, classify, error analysis

In the **elaborate** phase, the students are involved in activities that have them to apply, extend, or elaborate on the concepts and/or processes they explored. Students are applying information learned in the previous phases to new situations and are asking questions such as: "What happens if…" "Can I find a way to ..? This information could also be used to propose solutions, make decisions, and design experiments. At this level, the teacher should expect students to correctly use vocabulary, definitions, and explanations.

Activities that help students elaborate and apply learning to real-world situations include:

- Problem solving
- Decision making
- Experimental inquiry
- Thinking skills activities: compare, classify, apply

In the final phase, **evaluate**, students work with each other to check their understanding. Students are expected to ask each other open-ended questions based on evidence, observations, and previous explanations. The teacher provides feedback on their explanations. The teacher has the option to complete a formal evaluation and/or administer a test to determine students' level of achievement (Bybee et al., 2006).

Activities that assess student performance and/or understandings of concepts, skills, and processes, include:

- Using a scoring tool or rubric
- Using a performance assessment
- Producing a product

- Producing a Portfolio

Lesson Plan Example

The following is a brief lesson plan outline that uses the 5E instructional strategy for primary grades. This plan is adapted from the website energy4me.org. This site has a variety of lesson plans and activities that use the 5E strategy.

Objective/Topic: The students will understand the process that leads to the formation of sedimentary rocks and fossils fuels. They will understand how the remains of plants and animals are used to create oil.

Engagement- The teacher poises one or more of the following questions:
Are dinosaurs in your gas tank?
How are oil and gas created?
Did you know that oil and gas are fossil fuels?
Do you think it's possible to use old fossils to make oil and natural gas?
How long does it take to make fossil fuels?

Exploration- The students are divided into groups to conduct a scientific experiment. The structure and design of this experiment helps students observe how earth layers and fossil fuels are created. This activity is conducted over a 2 to 3 day time span.

Explanation- The teacher explains how fossil fuels are formed by presenting material from a textbook, science journal, or internet source. This explanation integrates the content and learning from exploration phase. Attention is also given to formally define words just as sediments, fossil fuels, and sedimentary rocks.

Elaborate- Student activities for this phase include creating a fossil imprint, comparing fossils, and creating a model that demonstrates the process of fossil fuel formation.

Evaluation- Student comprehension of this topic could be accessed through a student test, a student questionnaire, or a journal entry in a science notebook.

Concept Attainment Model

Concept attainment is an inquiry-based instructional strategy that is appropriate for teaching concepts that have a clear set of attributes. Concepts have a name, a definition, examples, and critical attributes or characteristics. They are also ideas or abstractions that are formed by putting data into observable categories (Lemlech, 2010).

The major emphasis of this model is to allow students to create their own definitions and understanding. Teacher planning is essential for this strategy. Before teachers present concepts, they will to decide the concepts' essential characteristics and develop a list of positive and negative examples that illustrate the concept. For example, a robin, hawk, eagle, and spider are positive examples of a predator while a truck, cow, computer, and rabbit are non-examples of predators.

At the beginning of a concept attainment lesson, the teacher needs to briefly explain to the students how they will figure out the "mystery" based on the words that are being presented. (Please note that pictures could also be used.) The students should be looking at three columns labeled: Yes, No, and Hypotheses. The "Yes" column will list the concept examples and the "No" column will reveal the non concept examples. In the "Hypotheses" column, the teacher records the students' guesses.

The teacher strategically presents the examples and non-examples. This sequence will determine the degree or level of difficulty for generating accurate hypotheses. As this process unfolds, the teacher reminds the students that their hypotheses are based on the presented information. Student hypotheses or guesses should be recorded and crossed out. This will help to check and support their responses.

This model allows students to observe and think logically about a concept and use evidence to support their hypotheses. The teacher helps students develop the concept's label and definition by keeping their focus on positive examples. The students should be allowed to test their hypothesis to help them solidify the concept's definition. In the final phase of this process, the teacher and students discuss their steps so they can understand how they arrived at that definition (Lemlech, 2010).

In closing, inquiry and inquiry-based strategies are vital for increasing elementary school students' love and enthusiasm for science. These methods encourage and enhance their natural curiosity and motivation for learning and connect science to students' everyday life. Inquiry and inquiry-based strategies helps students to develop a deeper understanding of science and create new scientific discoveries.

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