The Importance of Engaging Young Students in Science and STEM

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The Wonders of Science!

- Children are born with an innate curiosity of the natural world.
- Historically, school systematically removed that curiosity out of children.
- It is our job to as educators, at all levels, to bring back and foster that natural curiosity for learning and the natural world. By doing so, we will develop problem solving, critical thinking, curiosity, and many other important life skills so that children are ready to engage as productive citizens of the world.
Wonders of the Mekong: A Phenomena in Phnom Penh
Zeb Hogan - National Geographic Explorer / Monster Fish - describes the Phenomena.
Research Question: How many fish migrate from the Tonle Sap Lake down the Tonle Sap River and to the Mekong river?

Complication: the Tonle Sap river CHANGES DIRECTION every 6 months?

Claim: 5 Billion Fish.
Phenomena: In Cambodia, the Tonle Sap River Flows in different directions every six months....
Tonle Sap Lake / River to Phnom Penh
a tributary of the Mekong River
What do we need to know in order to begin to understand this phenomena?
Using Natural Phenomena to drive student inquiry

This is what real research and Science / STEM teaching looks like:

- Research question
- Claim
- Evidence / more evidence
- Modeling to verify evidence
- Reasoning
- Argumentation - Communicate your updated claim based on evidence
What is STEM?
What is Science?

“Science is both a body of knowledge that represents current understanding of natural systems and the process whereby that body of knowledge has been established and is being continually extended, refined, and revised” (Taking Science to School, 2007 p 27).

Science is built up of facts as a house is built of stones; but a collection of facts is no more science than a pile of stones is a house”

*Henri Poincare, La Science et l’Hypothèse (1908)*
What is Technology?

Anything human-made that is used to solve a problem or fulfill a desire. Technology can be an object, a system, or a process. (Engineering is Elementary)

technology [tek-nol-uh-jee]
noun 1. the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science.

What is Engineering?

The American Engineers' Council for Professional Development has defined "engineering" as:

The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation or safety to life and property.
What is Mathematics?

Mathematics has no generally accepted definition. Different schools of thought, particularly in philosophy, have put forth radically different definitions. All are controversial. (Wikipedia)

Mathematics - The science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations. (Merriam – Webster)

http://www.merriam-webster.com/concise/probability%20theory
What is STEM Education

STEM is Science, Technology Engineering and Mathematics - put together...

With the limited research about integration of the S.T.E. & M., the National Science Teachers Association (NSTA) refers to the concept of integrated STEM as an *instructional strategy* rather than a program or “discipline”.

STEM Education - Nevada Definition

STEM (Science, Technology, Engineering, and Mathematics) education focuses on active teaching and learning centered on relevant experiences, problem solving, and critical thinking processes. Stem Education emphasizes the natural interconnectedness of science, technology, engineering, mathematics and their connection to other disciplines* to produce informed citizens that possess and apply the necessary understanding to expand Nevada’s STEM capable workforce in order to compete in a global society.

*If STEM is taught properly, it will include Common Core L.A. and Math as well as history, culture, art and many other relevant subjects that STEM areas provide a context for study.
Proposed Purpose for STEM Education

• Knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural world and designed world, and draw evidence based conclusions about STEM related issues;

• Understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design;

• Awareness of how STEM disciplines shape our materials, intellectual, and cultural environments; and

• Willingness to engage in STEM related issues and with the ideas of science, technology, engineering, and mathematics as a constructive, concerned, and reflective citizen.

What does STEM Instruction Look Like?

“Applied” “Integrated” “Collaborative”

leads to “Instructional Strategies” that are based in Inquiry and utilize projects.

When STEM+ disciplines are integrated into solving a problem, working on interdisciplinary projects, and / or inventing things, the learning is said to be Problem Based Learning (PBL).

What is Inquiry and PBL?
Problem Based Learning (PBL)

Problem-based learning was developed in mid-1960s as an alternative method to traditional (Direct Instruction) (Bowdish et al., 2003; Loyens, Magda and Rikers, 2008).

Problem-based learning has been employed since then in other fields including business, education, law, nursing and engineering (Chen, 2008; Massa, 2008).

Problem-based learning is a learning method that uses problems as a basis for students to improve their problem-solving skills and to obtain knowledge through experience (Uden and Beaumont, 2005).

Three Levels of Problem Based Learning that integrate the STEM disciplines that match Levels of Inquiry: Structured, Guided, and Open Ended.

PBL is one instructional approach to Inquiry teaching.
Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p. 23)
Instructional Continuum

Direct Instruction (Behaviorist) ___________________ Inquiry (Constructivist) ___________________

Lecture Demonstration Skills Practice Structured Guided Open

Teacher Role:
(Sage- teacher centered) Teacher Role:
(Guide - student centered)

Student Role:
(Kinesthetically & Cognitively Passive) Student Role:
( Kinesthetically & Cognitively Active)

Continuum of Inquiry has been well documented in Science Education:
(Schwab, 1960; Atkins & Karplus, 1962; Herron, 1971; Bybee, 2002; Banchi & Bell, 2008)
### Figure 1.
The four levels of inquiry and the information given to the student in each one.

<table>
<thead>
<tr>
<th>Inquiry Level</th>
<th>Question</th>
<th>Procedure</th>
<th>Solution</th>
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<tbody>
<tr>
<td>1—Confirmation Inquiry</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Students confirm a principle through an activity when the results are known in advance.</td>
<td></td>
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<tr>
<td>2—Structured Inquiry</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Students investigate a teacher-presented question through a prescribed procedure.</td>
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<tr>
<td>3—Guided Inquiry</td>
<td>✓</td>
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<td>Students investigate a teacher-presented question using student designed/selected procedures.</td>
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<tr>
<td>4—Open Inquiry</td>
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<tr>
<td>Students investigate questions that are student formulated through student designed/selected procedures.</td>
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“Science is something students do, not something that is done to them.”
Early Childhood and Science / STEM
Science Ed research shows that a child’s Science attitude and belief about science is formulated by the end of 3rd grade (ages 8-9) (Featherston, 1999).

There is still a lot to learn about children and their science ideas and identities up to eight years old (Fleer & Robbins, 2003).
Twenty-five years of lit review show that:

- Children develop mini theories about their environment based on their own cultural or everyday experiences.

- Children’s existing ideas may or may not match those of school science.

- Children make sense of the science ideas or lessons in relation to the existing ideas they hold.

- Differences in children’s everyday or cultural ideas and school science cause variations in how children make sense of science lessons.

- Some children’s ideas do not change as a result of science instruction.
NSTA and Early Learning of Science
Position Statement endorsed by the National Association for the Education of Young Children (NAEYC).

At an early age, all children have the capacity and propensity to observe, explore, and discover the world around them (NRC 2012).

These are basic abilities for science learning that can and should be encouraged and supported among children in the earliest years of their lives.

The National Science Teachers Association (NSTA) affirms that learning science and engineering practices in the early years can foster children’s curiosity and enjoyment in exploring the world around them and lay the foundation for a progression of science learning in K–12 settings and throughout their entire lives.
Current research indicates that young children have the capacity for constructing conceptual learning and the ability to use the practices of reasoning and inquiry (NRC 2007, 2012).

Many adults, including educators, tend to underestimate children’s capacity to learn science core ideas and practices in the early years and fail to provide the opportunities and experiences for them to foster science skills and build conceptual understanding (NRC 2007, p. vii).

Also underestimated is the length of time that young children are able to focus on science explorations. Effective science investigations can deeply engage young children for extended periods of time, beyond a single activity or session.
NSTA and Early Learning of Science

key principles to guide the learning of science among young children

- Children have the capacity to engage in scientific practices and develop understanding at a conceptual level.
- Adults play a central and important role in helping young children learn science.
- Young children need multiple and varied opportunities to engage in science exploration and discovery (NAEYC 2013).
- Young children develop science skills and knowledge in both formal and informal settings.
- Young children develop science skills and knowledge over time.
- Young children develop science skills and learning by engaging in experiential learning.
1. Both parents and teachers appear to be enthusiastic and capable of supporting early STEM learning; however, they require additional knowledge and support to do so effectively.

2. Teachers in early childhood environments need more robust training and professional development to effectively engage young children in developmentally appropriate STEM learning.

3. Parents and technology help connect school, home, and other learning environments like libraries and museums to support early STEM learning.
4. Research and public policies play a critical role in the presence and quality of STEM learning in young children’s lives, and both benefit from sustained dialogue with one another and with teachers in the classroom.

5. An empirically-tested, strategic communications effort is needed to convey an accurate understanding of developmental science to the public, leading to support for meaningful policy change around early STEM learning.

STEM Starts Early (2017) Recommends

- **Engage**: Engage parents: Support parent confidence and efficacy as their children’s first and most important STEM guides
- **Support**: Support teachers: Improve training and institutional support for teaching early STEM
- **Connect**: Connect Learning: Support and expand the web of STEM learning “charging stations” available to children
- **Transform**: Transform early childhood education: Build a sustainable and aligned system of high quality early learning from birth to age 8
- **Reprioritize**: Reprioritize research: Improve the way early STEM research is funded and conducted
Early STEM Matters (2017): Guiding Principles

1. Children need adults to develop their “natural” STEM inclinations
2. Representation and communication are central to STEM learning
3. Adults’ beliefs and attitudes about STEM affect children’s beliefs and attitudes about STEM
4. STEM education is not culturally neutral
Early STEM Matters

Recommendations:

**Messaging:** Raise the profile and understanding of early childhood STEM education via advocacy and messaging

**Teacher Preparation:** Revamp pre-service and in-service STEM-related training and supports for early childhood teachers

**Parents and Family:** Establish initiatives, resources, and supports that promote parents’ and families’ involvement and engagement in their young children’s STEM education
Early STEM Matters

Recommendations:

Classroom Resources: Make high-quality resources and implementation guidance available to practitioners

Standards: Ensure that early learning and development standards explicitly address the STEM disciplines and align with K-12 standards

Research: Develop and support a research agenda that informs developmental trajectories, effective resources, and best practices in early childhood STEM education.

Children need adults to develop their “natural” STEM inclinations.
In conclusion....

Kids love science and STEM – Foster that creativity as parents and teachers

We need the entire “village” to work on early learning science / STEM learning – School, museums, communities, etc.

Early childhood learning, especially in science an STEM need to be a priority in funding and research.

Early Learning standards that match the trajectory of the Framework for K-12 Science Education and Next Generation Science Standards (NGSS) need to be developed

Teachers need the resources, professional development, tools and materials for successful science / STEM learning
This is why Early Childhood STEM Matters!
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