A Dozen Reasons Why We Need High Quality Science Teaching and Learning in a 21st Century World

Because of the requirements of No Child Left Behind and the current emphasis on implementing the Common Core standards, reading and math are given priority time and attention in many, if not most public schools and Districts. Due to these circumstances, there is relatively little priority given to teaching and learning science. We frequently read in the media about the importance of science in today's 21st century world, yet there is little emphasis on creating comprehensive, high quality science programs at all levels, pre-school through high school. It is rare to find coherent, active learning, inquiry based science programs at the pre-school and primary grade levels. Many teachers at the elementary level indicate that they have limited time to include science activities in the curriculum. High quality science programs emphasize active learning through inquiry strategies, investigation, hypothesis testing, experimentation, and science projects, but in too many middle and high school science classes, the key science program ingredients are the use of textbooks as the primary science resource, coverage driven teaching and learning, and traditional multiple-choice, short essay tests. Other priorities, time limitations, lack of attention, fragmentation, a traditional coverage based focus – all conspire to reduce the effectiveness and excellence of science programs in most schools and Districts.

Here are one dozen reasons why we must counter these trends and find ways to implement high quality science teaching and learning for all our children at all educational levels:

1. ***Science is interesting, important, meaningful, and motivating.***

Science questions provoke interest in the mysteries and wonders of the natural world. Students learn to think about important questions, such as: What is the nature of the universe? How does life exist? Why do things grow? Learning science provides students with an understanding of its massive contributions to everyday living and the comforts of life. Science programs provide an important avenue for helping students to develop a passion for inquiry and a better understanding of the world around us.

2. ***Science career opportunities will be important in the future.***

High quality science education experiences develop scientific talents and interests. Good science programs interest, motivate and encourage students to prepare to work in the growing science-related professions, as scientists, health care professionals, technicians, and other science-related fields.

3. ***Science promotes democratic thinking and values.***

Science teaches children to be open to new ideas and new ways of thinking in order to resolve problems. Conflicts in science are resolved peacefully through discussion, argument, further investigation and the collection of evidence. Scientists learn to "disagree without being disagreeable". Thoughtful criticism is the norm, not the exception. The expectation is that, as Einstein once said, "critical comments should be taken in a friendly spirit".

4. ***Science builds positive lifelong learning habits, behaviors and attitudes.***

Good science programs emphasize the value of inquiry, encourage curiosity, and reward persistence and patience. Students learn to focus on science as a series of mysteries. They learn how to develop and explore interesting questions. They learn to solve problems and answer questions by taking small steps, being persistent, having patience, and overcoming adversity. They learn that finding "truth" is often messy and inconclusive. Students learn that successful achievement and learning often require trial and error, making mistakes, even failure. In other words, science teaches habits, behaviors and attitudes that support self-directed, autonomous, lifelong learning.

5. ***Science enhances creativity and imagination, tolerance for and adaptation to change***

High quality science programs encourage students to ask "what if…?". Students learn to explore open-ended questions, to consider alternatives that are "outside the box", to invent and test creative solutions, and to try to solve problems in different and unusual ways. Science teaches students that change and adaptation is part of the nature of learning and growing by testing new ideas and adapting to changing circumstances.

6. ***Science teaches that knowledge is "tentative" and that knowledge, theory and explanation are all part of the learning process.***

Too many students come away from school thinking that that knowledge is fixed and immutable (especially if it comes from a textbook) – that there is always a right answer. A study of Galileo's or Einstein's discoveries help students to see that what once was thought to be "correct" turned out to be wrong, that scientific knowledge needs to be tested, studies need replication, and theory is only an empty idea until there is data to support and explain it. Good science programs teach students that knowledge is frequently tentative and changing.

7. ***Science develops critical intellectual skills.***

Science fosters the development of critical thinking skills that carry over to learning other subjects and daily living. Through science, children learn to carefully observe (What do you see happening to this plant as it grows?) interpret and hypothesize (Why do you think this is happening?) conduct experiments (How can we prove it?), see different perspectives and points of view (What are different points of view about why this happened?) analyze (What are its component parts?) synthesize (How does this all fit together into a pattern? What are the connections and relationships?) and draw conclusions (What are our results? Conclusions? Why?) Students learn how to create an argument with supporting evidence to justify a point of view, to question opinions that have little backing to support them.

8. ***Science builds reading and "learning to learn" skills.***

Good science programs build strong reading skills! As students investigate physical forces, chemical reactions, biological growth, or the solar system, they also learn how to read a variety of science resources, understand new concepts, build vocabulary and background knowledge, and learn the language of science and science inquiry. The investigation skills they learn – defining problems and challenges, searching for and

processing information, thinking critically and creatively, drawing conclusions and applying learning, and communicating with others and explaining results - are a significant part of the "learning to learn" skills they will need for college and future careers.

9. Science helps students to learn and apply mathematical thinking.

Math is the language of science. As students learn science, they learn that mathematics is an important tool to help solve real problems and questions. Measurement, number manipulation, and proportional thinking are critical tools of science. As students "do" science, they learn how to collect and analyze data, form patterns, develop spatial and geometric relationships, and apply many of the higher level and complex math systems to scientific problem solving.

10. Science enriches learning in other subjects.

All subject areas benefit when a student understands science concepts and ideas. For example, science concepts are helpful for understanding historical forces, technological and social changes over time, and current issues and concerns such as global warming. Science problems can be used to help students understand and apply statistical analysis. The arts are integrated into science through graphic designs and drawings that complement learning about scientific and technological principles and innovations and provide visual demonstrations of learning. Science concepts are intertwined with understanding healthy living habits and good nutrition.

11. Science develops teamwork skills.

Through science, children learn how to work together to investigate, test hypotheses, interpret data, and draw conclusions. As they work together, they learn to understand and tolerate difference and diversity. They learn how teamwork contributes to significant learning. Science can also contribute to making schools safer and more peaceful by teaching students how to work together and resolve conflicts.

12. Scientific understanding is critical for good citizenship in a 21st century world.

An understanding of science, science concepts, how science arrives at results, and science research is critical if students are to become intelligent citizens in a democratic society. An understanding of today's complex issues, concerns, challenges and problems require an understanding of scientific principles, concepts and ideas. Global warming is the most obvious, but others include what to do about atomic waste, how to get clean water, agriculture and food issues, health and illness, hurricane damage prevention, energy issues, automation and robotics.

Conclusion

High quality, inquiry based science programs motivate children and provide them with intellectual skills and positive attitudes and values that help them to succeed in school and in life. Science learning raises and examines critical questions and promotes understanding about the natural and physical world, and provides students with inquiry and investigation skills that will encourage a lifetime of learning. They increase interest

in a subject that is of considerable importance to the development of highly educated citizens who understand critical issues for the future and to student preparation for well-paying science-related careers. Good science programs help students learn to work together and to learn methods that help them resolve conflicts peacefully.

Teachers, Boards of Education, superintendents, principals, the community at large, and governments at all levels – all need to make a commitment to support and develop high quality science programs at all levels, including pre-school. There are many ways to do this – for example, to widely share and discuss these dozen reasons on why it is critical to develop strong science programs, to adopt high quality science curricula at all levels[1], to develop teachers' science knowledge and skills, to train teachers on how to incorporate high quality science experiences into their classrooms, to involve local science organizations in promoting and fostering high quality programs, to apply for funds to implement and support high quality science programs at all levels, and, ultimately, to develop competent science educators in every school and at all levels.

Every child should have the opportunity to participate in a strong, coherent science program. It should be priority for a 21st century world education. Science education can have a powerful impact on children and learning, and it can make a significant difference in the lives of children. What it takes is understanding, commitment, dedication, passion, persistence, and hard work over time.

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[1] Curricular programs that meet the high quality test include active, kit based elementary science programs such as FOSS (http://lhsfoss.org), secondary programs such as Active Physics (http://its-about-time.com/htmls/ap.html), and the adoption of teaching methods that promote active learning and support science understanding, such as those created by Eric Mazur at Harvard University (http://mazur.harvard.edu/education/educationmenu.php).

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