Perspectives of Hands-On Science Teaching

David L. Haury and Peter Rillero, 1994

2. What are the benefits of hands-on learning? How do I justify a hands-on approach?

Teachers who embrace hands-on learning in science seem to recognize certain desirable outcomes and endorse student-centered instructional approaches. Research has confirmed many of the seemingly intuitive benefits of hands-on learning and has also documented a variety of unanticipated benefits. But what effects of hands-on learning are seen by advocates as most important or valuable?

Teacher Responses

- Students in a hands-on science program will remember the material better, feel a sense of accomplishment when the task is completed, and be able to transfer that experience easier to other learning situations. When more than one method of learning is accessed as in hands-on learning, the information has a better chance of being stored in the memory for useful retrieval. Students who have difficulty in the learning arena for reasons of ESL barriers, auditory deficiencies, or behavioral interference can be found to be on task more often because they are *part of* the learning process and not just spectators.
- Justifying why I would use hands-on science is based on all the research and methods studies that are current. They support the notion of multi-faceted bombardment of information and experiences so that the retention level is improved. Students who are involved in labs and activities are empowered in their own learning process. *Mary Wieser, French Prairie Middle School, Woodburn, OR*
- The benefits of hands-on-learning in my school revolves around those children who are either not as academically "talented" or have not shown "interest" in school. This method tends to stimulate these type [of] students into participating and eventually absorbing information that I believe they would not get from "normal" *show-me - tell-me* methods. *Marv Hougland, seventh and eighth grade teacher, Clearview School, Lorain, OH*
- The single most important benefit to me is that although it requires a great deal of preparation time, once a system is developed, hands-on teaching makes teaching fun. If the kids are learning and having fun doing it, then I am having fun at my job, and I am a happier person overall. *Jeff G. Brodie, fifth and sixth grade teacher, East Side Elementary, Edinburgh, IN*

Developer Thoughts

- ***I hear and I forget***
  I see and I remember
  I do and I understand

  - Chinese Proverb

Although these words may not be the exact translation, they underscore the need for a hands-on approach to science teaching. Without this approach students must rely on memory and abstract thought, two methods which restrict learning in most students. By actually doing and experiencing science, students develop their critical thinking skills as well as discover scientific concepts. This self discovery stays with students throughout their lifetimes while memory fades. *Carol J. Stadum, The Planetary Society (producers of Marslink teaching packets), Pasadena, CA*

- If students are not doing hands-on science, they are not doing science. Science is a process and if students are not actively engaged in the process, they are not doing science. Most science classes in elementary school teach the vocabulary of science and nothing else.

  Study after study has shown the value of hands-on learning. Students are motivated, they learn more, even their reading skills improve. How can you justify not doing hands-on science? *Edwin, J.C. Sobey, National Invention Center, Akron, OH*

- Learning by well-planned activities and experiences in a well engineered program is a quality instructional approach. It:
  - causes students to rely on the evidence instead of upon authority (encyclopedia, minister, doctor, text, teacher, parent). Most students live in an authoritarian world with little or no opportunity to practice decision-making because nearly everyone tells students what to do and when to do it. We continually graduate students who do not yet have the ability to set up a simple experiment with controlled variables, collect and interpret evidence, or make correct interpretations based upon that evidence.
  - provides students with a similar set of experiences so everyone can participate in discussions on a level playing field regardless of their socio-economic status. In this way, special benefits are not awarded to those who, by virtue of their wealth or background, have a greater number of experiences under their belts.
  - forces student thinking by requiring interpretation of the observed events, rather than memorization of correct responses.
  - messages the learner that they, as well as the instructor, can interpret data, and that various interpretations are possible and often probable. When a text or teacher tells students that plants need light to grow (an untruth) students simply memorize this without question and are hampered by the falsehood for a lifetime. However, when a student personally germinates seeds in the dark and finds that they grow taller than seeds grown in the light, it has irrefutable evidence from a personal experience that plants do not need light to grow. Because he now has evidence that light inhibits growth (which it does) he now has a chance of figuring out why plants in a house grow toward the light (cell growth of the lighted side of the stem is repressed while the unlighted side grows more, thus causing the stem to grow in such a manner as to aim the upper part of the plant toward the light which is necessary for growth after the stored food energy is used up.) This information seldom comes from K-6 texts or teachers , yet is a logical interpretation by 10 year old students *if they conduct the experiments*. It:
    - encourages questioning of the observed events and the resulting data. When students carry out their own experiments, they become very familiar with the events and the variables involved.
    - promotes cause and effect thinking.
    - reduces dependence upon authority. Practical experiences in generating hypotheses and planning experiments now, will make the students more independent later when they no longer have authorities standing by at every turn of their lives. *Robert C. Knott, Ed.D. Science Curriculum Improvement Study 3, University of California, Berkeley*
- The importance of providing children with direct experiences with materials, objects, and phenomena is supported by experience and understanding of how learning takes place. While information can be

remembered if taught through books and lectures, true understanding and the ability to use knowledge in new situations requires learning in which children study concepts in-depth, and over time and learning that is founded in direct experience. Therefore, the justification for hands-on learning is that it allows students to build understanding that is functional and to develop the ability to inquire themselves, in other words, to become independent learners. *Karen Worth, Education Development Center, Inc. (Developers of Insights: A 1), Newton, MA*

Notes from the literature

- "Hands-on and learning by experience are powerful ideas, and we know that engaging students actively and thoughtfully in their studies pays off in better learning (Rutherford, 1993, p. 5).
- Recipe for a Science Lesson

  Option 1: Find a puddle and photograph it. Show the photograph to a seven-year-old child. Have her read about puddles. Later, ask her to talk about the puddle.

  Option 2: Find a puddle. Add one seven-year-old child. Mix thoroughly. Stomp, splash, and swish. Float leaves on it. Drop pebbles into it and count the ripples. Measure the depth, width, and length of it. Test the pH. Look at a drop under a microscope. Measure 250 mL of puddle water and boil it until the water is gone. Examine what is left in the container. Estimate how long it will take for 250 mL of puddle water to evaporate. Time it. Chart it. Now ask the child to talk about the puddle.

  If you were a seven-year-old child, what option would stimulate you to talk about the puddle? That's what hands-on science is all about - allowing students to experience science fully" (Donivan, 1993, p. 29).

- Piaget stressed the importance of learning by doing, especially in science. According to Piaget, "a sufficient experimental training was believed to have been provided as long as the student had been introduced to the results of past experiments or had been allowed to watch demonstration experiments conducted by his teacher, as though it were possible to sit in rows on a wharf and learn to swim merely by watching grown-up swimmers in the water. It is true that this form of instruction by lecture and demonstration has often been supplemented by laboratory work by the students, but the repetition of past experiments is still a long way from being the best way of exciting the spirit of invention, and even of training students in the necessity for checking for verification" (1986, p. 705).
- "Piaget's research clearly mandates that the learning environment should be rich in physical experiences. Involvement, he states, is the key to intellectual development, and for the elementary school child this includes direct physical manipulation of objects" (McAnarney, 1978, p. 33).
- Bruner also stressed learning by doing. "The school boy learning physics is a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else" (Bruner, 1960, p. 14). Bruner states, "Of only one thing I am convinced. I have never seen anybody improve in the art and technique of inquiry by any means other than engaging in inquiry" (1961, p. 31). Bruner points out the quick rate of change in our world and says, "the principal emphasis in education should be placed on skills - skills in handling, in seeing, and imaging, and in symbolic operations" (Bruner, 1983, p. 138).
- A hands-on approach is also advocated by some people who advocate a constructivist approach to science teaching. "Learning is defined as the construction of knowledge as sensory data are given meaning in terms of prior knowledge. Learning always is an interpretive process and always involves construction of knowledge.... Constructivism implies that students require opportunities to experience what they are to learn in a direct way and time to think and make sense of what they are learning. Laboratory activities appeal as a way of allowing students to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science" (Tobin, 1990, p. 404-405).
- Educational research has shown many advantages of using hands- on science programs. Bredderman (1982) reports the results of a meta-analysis of 15 years of research on activity-based science programs.

This synthesis of research was based on approximately 57 studies involving 13, 000 students in 1, 000 classrooms. All of the studies involved comparing activity-based programs (the Elementary Science Study, Science-A Process Approach, or the Science Curriculum Improvement Study) with comparable classrooms using a traditional or textbook approach to science teaching. A variety of student performance measures were analyzed. The most dramatic differences were found in science process skills where the students in activity-based programs performed 20 percentile units higher than the comparison groups. The students in these programs scored higher than the control groups in the following measures (ranked from largest to smallest differences): creativity, attitude, perception, logic development, language development, science content, and mathematics. Students who were disadvantaged economically or academically gained the most from the activity- based programs.

- Hands-on learning has been shown to increase learning and achievement in science content (Bredderman, 1982; Brooks, 1988; Mattheis & Nakayama, 1988; Saunders & Shepardson, 1984).
- Research indicates that activity-based science can improve students' attitudes toward science (Jaus, 1977; Kyle, Bonnstetter, Gadsden, & Shymansky, 1988; Kyle, Bonnstetter, McCloskey, & Fults, 1985; Rowland, 1990). "There seems to be some evidence from exemplary programs that even poorly taught hands-on science is more interesting to students than the typical textbook based program" (Penick & Yager, 1993, p. 5).
- Evidence clearly indicates that hands-on activities increase skill proficiency in processes of science, especially laboratory skills and specific science process skills, such as graphing and interpreting data (Mattheis & Nakayama, 1988).
- Hands-on learning in science has been shown to help in the development of language (Bredderman, 1982; Huff, 1971; Quinn & Kessler, 1976) and reading (Bredderman, 1982; Morgan, Rachelson, & Lloyd, 1977; Willman, 1978). Morgan, Rachelson, and Lloyd (1977) concluded from their study that "sciencing activities can make a positive contribution to the acquisition of reading skills of first grade students. These activities can provide the concrete experiences from which many reading skills are derived" (p. 143).
- Participation in science inquiry lessons facilitated development of both classification and oral communication skills of bilingual Mexican-American third grade students (Rodriguez & Bethel, 1983).
- From their analysis of educational research, Barufaldi and Swift (1977) concluded that, "a definite trend emerges that science experience enhances reading readiness skills and oral communication skills among children" (p. 392).
- Activity-centered classrooms encourage student creativity in problem solving, promote student independence, and help low ability students overcome initial handicaps (Shymansky & Penick, 1981).
- "Seen only as a laundry list of theorems in a workbook, science can be a bore. But as a 'hands-on' adventure guided by a knowledgeable teacher, it can sweep children up in the excitement of discovery. Taught by the regular classroom teacher, it can illustrate the point that science is for everyone - not just scientists" (William J. Bennett (as U.S. Secretary of Education), 1986, p. 27).

Summary

There are a plethora of benefits that teachers and curriculum developers adduce to hands-on learning to justify the approach in science. Benefits for students are believed to include increased learning; increased motivation to learn; increased enjoyment of learning; increased skill proficiency, including communication skills; increased independent thinking and decision making based on direct evidence and experiences; and increased perception and creativity. Research supports many of these claims by providing evidence that the learning of various skills, science content, and mathematics are enhanced through hands-on science programs. Students in activity-based programs have exhibited increases in creativity, positive attitudes toward science, perception, logic development, communication skills, and reading readiness. These benefits seem more than sufficient justification for promoting hands-on learning. However, Jeff Brodie provided an important addition - it makes science fun for both the student and teacher. Given the recent concerns about science anxiety and avoidance, enjoyment of science learning seems a worthy goal to be considered in choosing instructional approaches in science.

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Contact: info@ncrel.org