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ABSTRACT

Changes in work and the workplace have made competing demands on school reform: higher standards and expectations for academic achievement as well as technical competence and ability to apply knowledge in context. Therefore, educators must discover how academic subjects such as science can be a more integral part of career and technical education (CTE). The National Science Education Standards provide guidelines for improving K-12 science education; in regard to CTE they specify learning through inquiry, hands-on learning, minds-on learning, and process skill development. These four areas are important to CTE because they focus strongly on problem-solving skills and can be easily linked to real-world applications. Work-based learning (WBL) experiences in science could further science literacy and science career interest. Some schools are taking novel approaches to integrating science and WBL activities, for example, Turner Technical Arts High School in Miami applies biology concepts to real-world situations, such as extracting DNA from fresh vegetables. In order to achieve science literacy, "science at school should resemble science at work" (M. Vickers 1998). As students learn to analyze and solve workplace problems using the inquiry-based methods of science, they need to be introduced to the techniques and concepts that are used by professionals. A combination of reform efforts such as the National Science Education Standards and the school-to-work movement can help bridge the gap between academic and occupational learning and between abstract, decontextualized knowledge and practical, contextualized knowledge. (Contains 12 references.) (KC)

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IN Brief
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National Dissemination Center for Career & Technical Education

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Integrating Science Education and Career and Technical Education

Science is a subject we encounter every day–cellular phones, pagers, computers, e-mail, web pages are all current contact points with science and technology. Science and technology are integrated into our daily routine, and knowledge of both is paramount to success in the workplace, which makes them essential for all students. However, science and other academic subjects have traditionally functioned as "exclusive" disciplines, and performance in these subjects has been used to determine who will follow which track: college prep or vocational education (Vickers 1998). In academic knowledge, the abstract has been valued above the practical, and the "pure" more than the "applied."

Changes in work and the workplace have made competing demands on school reform: higher standards and expectations for academic achievement as well as technical competence and ability to apply knowledge in context. Therefore, educators must discover how academic subjects such as science can be a more integral part of career and technical education (CTE). This Brief considers what science brings to CTE and what CTE can do for science in an integrated curriculum.

National Science Education Standards and CTE

Recognizing the need for improved science literacy by all students, *Science for All Americans* (American Association for the Advancement of Science [AAAS] 1990) emerged from Project 2061, an effort to improve science education in a way that would result in a scientifically literate society by the year 2061. To achieve this goal, the *National Science Education Standards* (NSES) provide guidelines for improving K-12 science education. One of the goals of the standards is to educate students who are able to "increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers" (National Research Council 1996, p. 13). The impact of changing workplace technology makes it clear that scientific literacy is vital for many kinds of jobs in today's workplace (Gaskell and Hepburn 1997).

Although the science standards are focused primarily on improving science learning specifically, a number of the methods they recommend are relevant to CTE programs, allowing for development of science literacy skills while focusing on career and technical issues. These include learning through inquiry, hands-on learning, minds-on learning, and process skill development. What makes these four areas important to CTE?

- Strong focus on ***problem-solving skills***. Students are taught to reason, observe, deduce, and think through a problematic situation in order to obtain a rational resolution
- As mandated by NSES, each of these four areas can be easily linked to ***real-world applications***. Research has demonstrated that students learn better when the material is personally relevant and contextualized, that is, situated "in the context of real-life happenings and involving the solution of unstructured problems of the real world" (Brown 1999, p. 1).

Work-Based Learning Experiences and Science

The major national science reforms (NSES and Project 2061) call for real-world application of science learning and real-life experiences for all students in science. Another reform movement, school-to-work, has the following goals (Gaskell and Hepburn 1997): integration of academic and occupational learning, linking of secondary and postsecondary education, and integration of work-based learning and school-based learning.

Work-based learning (WBL) experiences in science could further science literacy and science career interest. WBL activities give students "an opportunity to apply academic knowledge and vocational skills to solve problems of the real world" (Brown 1998, p. 1). It is this real-world component that connects work-based learning with science education. The *Working to Learn* approach illustrates this connection:

> Instead of starting with abstract principles of science and adding applications as an afterthought, teachers begin with problems that arise at work or in the community, and introduce the scientific and mathematical ideas needed to identify and test possible solutions to those problems. (Vickers 1998, p. 110)

A goal of *Working to Learn* is to link science as it is used at work with science as it is presented in the ***Benchmarks for Science Literacy*** (AAAS 1993) and NSES. Research has shown that, in technical jobs, "academic skills are always used in some applied context" (Stasz and Brewer 1999, p. ix). Thus, science and CTE can benefit each other: career and technical educators have an opportunity to demonstrate the academic rigor of their programs while integrating science, and science instruction can be made less abstract for students when they see how it relates to life and work (ibid.).

Examples of Integrated Science and WBL Activities

The agriscience academy at Turner Technical Arts High School in Miami applies biology concepts to real-world situations. In one activity, students use readily available materials (beakers, detergent, a blender, salt, a test tube, among others) to learn how to extract DNA from fresh vegetables. In the process, they learn about DNA's fundamental properties as well as methods that can be used to improve plants for longer shelf life and better shipping, a matter of importance to agricultural production (Roberts 1999).

One *Working to Learn* activity has students investigate why people get headaches working in particular buildings (Vickers 1998). A qualified heating, ventilating, and air conditioning (HVAC) technician shows students how to conduct air quality measurements, how the HVAC system works, and how to troubleshoot it. Their teacher involves them in laboratory experiments and helps them connect the real-world problem with the science principles involved.

One of the integration strategies used at Rindge School of Technical Arts (Berman and Steinberg 1997) combines the teaching of technical procedures ("how") with teaching of the scientific principles underlying them ("why"). The school uses a design and problem-solving approach to teaching a project-based science course. For example, an assignment to design a car involves students in researching design principles; selecting methods, materials, and tools; using appropriate technologies; engineering their design; and evaluating and refining the result. In the process, the use of structural, mechanical, electrical, electronic, pneumatic and hydraulic, and solar systems provide an opportunity to teach the principles of physics.

Implications for Policy and Practice

To achieve science literacy, "science at school should resemble science at work" (Vickers 1998, p. 122). As students learn to analyze and solve workplace problems using the inquiry-based methods of science, "they often need to be introduced to techniques and concepts that are used by professionals. Most of these techniques are rarely taught in school science" (ibid., p. 113). However, integration of science and CTE will not be easy to achieve. What can be done to make it work?

- Assure parents and others that integrated curricula are "college ready" and meet state standards (Lozada 1999b).
- Demonstrate how applied science taught through CTE is linked to high-paying, skilled jobs and further education (Gaskell and Hepburn 1997).
- Enlist support from business, industry, and labor and postsecondary institutions (ibid.).
- Use tools such as the Benchmarks (AAAS 1993) to gauge how well scientific literacy is addressed in integrated curricula.
- Recognize that integration should be a completely different approach to teaching and learning that requires more planning time and collaboration and different ways to measure its effectiveness (Lozada 1999b).
- Clarify the role of vocationally certified and science-certified teachers in the development and teaching of integrated courses (Berman and Steinberg 1997).
- Provide ongoing professional development in science and math for CTE teachers (Lozada 1999a).

A combination of reform efforts such as the national science standards and the school-to-work movement can help bridge the gap between academic and occupational learning and between abstract, decontexualized knowledge and practical, contextualized knowledge. A unified effort offers motivation and purpose that makes it possible for standards to be addressed, used, and achieved.

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Online Resources

The following web links provide insights into work-based learning and science learning programs and sources of further information

National Science Teacher's Association's Pathways books guide standards implementation into elementary, middle, and high school classrooms: http://www.nsta.org/

National Science Education Standards: http://www.nap.edu/books/0309053269/html/index.html

Benchmarks for Science Literacy: http://www.project2061.org/tools/benchol/bolframe.html

Science for All Americans: http://www.project2061.org/tools/sfaaol/sfaatoc.htm

National School-to-Work Learning Center Links: http://www.stw.ed.gov/wwwsites.htm

National Science Foundation School-to-Work Project: http://www.womenpolice.com/html/womentech.html

Science Learning Network: http://www.sln.org/

Applications of Working and Learning Project is an online database of integrated lesson plans and activities collected from real workplaces <http://www.awal.ctt. bc.ca/>. Science is one of eight curricular areas in the database. Each lesson plan/activity provides the following: job information (job title, education requirements, career cluster), essential skills used; and application (problem, context, activity, online resources, correlation with British Columbia courses and standards).

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