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III EDUCATION

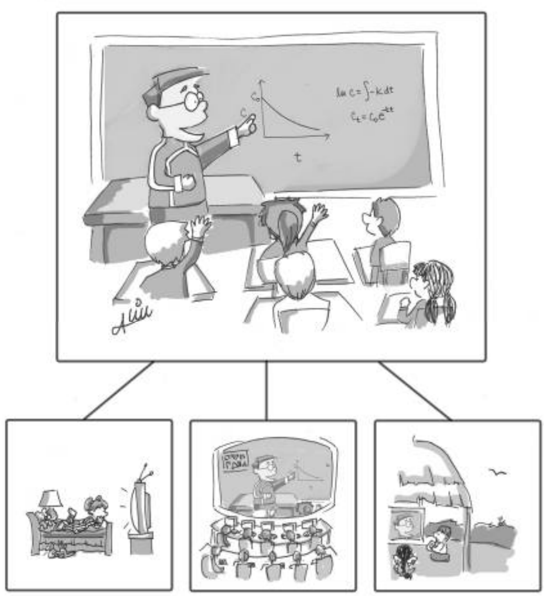
Chapter 20

Facing the Challenges in Educational, Technological and Social Change Leading to 2050

Jeff R. Wright

ABSTRACT

The evolution of the field of environmental and water resources engineering over the next half century will both shape and be shaped by changes in our natural and man-made environment, changes in society and what it expects from professionals, changes in technology, and changes in how we educate tomorrow's professional and technical workforce. While predicting *anything* 40 years into the future is initially daunting and ultimately humbling, this chapter presents a framework for anticipating the changes that will be needed in the way we educate environmental engineers. Particular attention is given to the expectation for new and emerging information and computational technologies, and opportunities and challenges for developing new educational pedagogies.



"Global Learning Community"

PERSPECTIVE

Evaluating attempts to predict the future with respect to important societal concerns, Princeton physicist Gerard K. O'Neill observed that forecasters tend to underestimate the rate of technical change, and overestimate the rate of social change (O'Neill 1981). This appears to be consistent with the rapid pace at which engineering innovation over the past several decades has provided technologies and methodologies that can improve water resources assessment and management, as well as the sluggishness with which widespread incorporation of such advances are mandated for use within comprehensive resource management programs. Slower still is the rate at which this innovation has motivated substantial changes in the undergraduate engineering curriculums.

Here I offer a number of prognoses of *technological change*, *social change*, and *educational change* that will challenge, and provide opportunities for, water resources professionals and educators between now and 2050.

Forecasters tend to underestimate the rate of technical change, and overestimate the rate of social change.

TECHNOLOGICAL CHANGE

Sustainable Distributed Energy Sources

Recent attention to concerns of energy independence, sustainability, and global warming will drive massive research and development investments in renewable energy sources and dramatically improve distribution and control systems (Sayigh 2008). This investment will produce cost-effective, modular and scalable sources of high-quality energy that will enable increasingly reliable water monitoring, assessment, management and control systems. Improved efficiencies, reliability, and maintainability of these systems will reduce the overall relative cost of providing sustainable water resources to all sectors of our economy. New technologies for energy storage will enable much more efficient load shifting and balancing that will in turn allow enhanced optimization of production and delivery systems.

Ubiquitous Environmental Sensor Technologies

New sensor technologies and methodologies for their use are being created at an ever increasing rate (Kanoun and Trankler 2004). Advances in modern sensor technology across all spatial and performance scales will continue and accelerate over the next 40 years. Smaller and more efficient sensors will be adaptable to widespread environmental and water resources monitoring systems, and will be more readily integrated into physical infrastructure to monitor performance and condition, which will improve service and reduce the cost of systems maintenance and operation. Sensor networks will become increasingly energy independent and able to collect and transmit data reliably and continuously as needed.

Remote Sensing and Earth Observation

Remote sensing and related earth observation technologies will advance quickly with much higher resolution and reliability. High resolution technologies will enable daily image capture from all populated areas with higher frequency data collection from sensitive or critical areas. Custom image capture perspectives and schedules will be readily available to engineers, scientists, and water authorities. Large scale data storage and central repositories will enable widespread access to these data.

Intelligent Visualization and Image Analysis Systems

New and continuously improved intelligent and adaptive systems will be created to perform real-time analyses of images and sensor signals. The information from the analyses of these images will be combined seamlessly with data from distributed sensor networks to provide immediate and reliable measurements of the condition and health of environmental and water resource systems. Autonomous learning agents and adaptive systems will form the structure for intelligent scene-driven data analysis algorithms, providing opportunities for the development of more cost effective and responsive early warning systems.

Adaptive Modeling Systems

Modeling will remain an important component of water resources planning and management and environmental engineering (Loucks 2008). While innovation will continue in the design and development of next generation modeling technologies and methodologies, major advances must be made in the use of this innovation. New development environments for model applications will emerge rapidly over the coming decades that will enable new opportunities for rapid prototyping of water resources models using fully emerging computing architectures including virtual distributed client-server networks and grid computers. Prototyping will enable rapid integration of state-of-the-art simulation and optimization algorithms as well as inferential algorithms. New gigapixel hardware output display devices such as 3D powerwalls, caves, and other immersive media systems (including networked systems supporting multiple users across space and time) will emerge, enabling exploratory evaluation of complex images for use by systems managers as well as water resources engineers and scientists (Wallace et al. 2005). These modeling and systems technologies will greatly expand the rate at which modern shared vision modeling environments can be developed for, and used by, water resources stakeholders (Perez and Viessman 2009).

Commonplace Open Information Management Systems

The interactive access and use of water resources models and data will be facilitated greatly by Open Information Management Systems (OIMS) which will become widely available and commonplace, enabled by explosive growth in the development and use of free and open source software. Transparent interfaces for the spectrum of input and output devices will enable systems to be designed and implemented by engineers and administrators without the need for extensive and expensive computational support staffs.

SOCIAL CHANGE

Increased Public Awareness of Water Issues

Expanded pressures on water resources from continued population growth (Table 20-1) and environmental pressures will become much more visible to the general public, with growth in size and number of better informed citizens action groups. These groups will hold municipalities and water authorities much more accountable for sharing information and water resources forecasts, and for providing regular updates on water-related and environmental issues. Daily water reports will become commonplace in print, broadcast and online media, and other public forums.

Table 20-1. Projected growth and change in US population demographics

Year	2005	2050
Population (millions) [1]		
World	**6,426**	**9,309**
United States	**296**	**438**
Shifts in U.S. Racial/ethnic groups [2]		
Foreign-born	12%	19%
White	67%	47%
Hispanic	14%	29%
Black	13%	13%
Asian	5%	9%

[1] U.S. Census Bureau (2008) [2] Passel and Cohn (2008)

Increased Public Pressure for Water Sustainability

Due in part to the increased availability of water resources information and public awareness, society will demand improved stewardship of this valuable resource to meet its needs for sustainable and reliable high quality water supplies. The decisions by water agencies and public officials responsible for water resources will be under increased scrutiny because of a larger and better informed citizenry. Water-related public expenditures and the stewardship of public infrastructure will be more visible and will provide the basis for citizen choices in public elections.

EDUCATIONAL CHANGE

Universal Technical General Education

The perspective on general education by most of our universities is that technical students must have broader backgrounds in the arts, humanities, and the social sciences. While certainly true, in this increasingly technical and complex society it will become increasingly important for non-technical students to obtain, through their formal education, a deeper understanding of technologies and sciences that impact their lives. This is nowhere more true than in areas of public welfare such as health care, environmental sustainability, and water reliability and quality assurance.

Universities will be under increasing pressure to provide technically-based learning experiences to all students, driven by the country's need to attract more K-12 students into technical careers, or careers that involve the management of technology. Stronger and more effective linkages and networks will be created between universities, community colleges, and K-12 institutions to improve the seamless transition of students into career paths that are more compelling for them because of the impact they will have on society.

Technical students must have broader backgrounds in the arts, humanities, and the social sciences and non-technical students must obtain a deeper understanding of technologies and sciences.

Technical Workforce Diversification

The next 40 years will experience not only rapid world and US population growth, but also dramatic demographic shifts (El Nasser 2008; Passel and Cohn 2008) as reflected in Table 20-1. Most dramatically, the US will no longer have a majority Caucasian population, with the fraction of White citizens dropping from 67% to 47%, while the Hispanic population will increase from 14% to 29% over the same period. With the Hispanic representation in the current US engineering workforce at less than 5.5% and the current enrollment in engineering undergraduate degree programs at fewer than 3.5% of total engineering students (NSF Engineering Task Force 2005), increasing Hispanic participation in engineering will be a top priority in the coming decades. Doing so will result in an influx of new talent and important new perspectives into the engineering workforce at the time when this is essential for the country. Strong and targeted recruitment pipeline facilitation efforts will emerge nationally, particularly in the US southwest.

Standard 5-Year Requirement for Engineering

By 2050 the majority of engineering programs in the US, particularly those disciplines that address most directly engineering problems in the public sector (e.g. civil engineering, environmental engineering, etc.) will transition to 5-year programs, many offering streamlined Bachelor of Science in Engineering/Master of Science emphasis programs. For water resources and environmental engineering students, this will enable broader exposure to information management and networking communications technologies, modeling and model development tools and techniques, data and database development technologies, and collaboration systems. Valuable internship and co-op experiences will become a formal and required component for most of these programs.

Global Learning Communities

Recent interest in the development of national and international learning communities will continue (Palloff and Pratt 2007; Smith et al. 2004) and become commonplace within the engineering community. These collaborations will include educational/research universities at multiple locations working as appropriate with leading private sector firms and government organizations. Curricula will become increasingly experiential learning-based, and be configured in a manner that will reduce the overall cost and redundancy of staffing and equipping more narrow, but higher quality programs. Courses will consist of flexible module choices within a connected theme, and will adapt most directly to specialized learning needs rather than teaching needs. The resulting curricula for a particular degree or certification will be offered by the very top faculty and professionals in the area regardless of physical location.

Lifeline Learning

Universities and learning communities will become an increasingly important part of a student's formal professional development throughout one's career. With improved networked communications methodologies and infrastructure, students will be able to remain linked to their formal education continuously and formally. Academic programs will transition from being a foundational experience for formal engineering education to one that is viewed explicitly as part of one's *lifeline learning* (Wright 2000); students will stay "connected" with their learning roots, and will nourish, as well as be nourished by that foundation.

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