An Historical Perspective on Water Resources Education

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Abstract

Historical perspective gives a foundation for understanding the present and evaluating options for the future. Education in water resources covers: 1) general knowledge in water related natural and social sciences, 2) professional capacity for managing water resources to serve public needs, and 3) specialized techniques to apply in research to support the first two purposes. The water engineer or hydrologist acquires general knowledge as a scholar of the liberal arts, specializes in a professional education, and keeps abreast of current research through continuing education. Curriculum development faces challenges in keeping the content of general education in harmony with the content of professional understanding and in effectively adding research results to both areas. The vast inertia that has been institutionalized into water education must be converted to a more dynamic process for keeping all three parts current in serving public interests, career needs, and knowledge building. From a broad understanding of natural systems and social preferences, professionals can contribute expertise to serve the public interest and find self fulfillment in a rewarding career.

Introduction

Water knowledge began with necessity and was expanded to achieve dreams. At various times, people: 1) experienced dire but short-term needs during floods and droughts, 2) saw long-term opportunities for economic gain by drawing water from streams and wells, and 3) found lakes and rivers to add a variety to their landscape that made life more enjoyable. People who wanted to alleviate suffering or improve their lives through water use hired professionals to build structural works and develop management policies. Water resources education was begun to transmit ideas and experiences to both the people who dreamed and the professionals who served them.

Functions of Water Education

In the modern world, education expanded to defining needs more precisely, finding ways to fulfill them more efficiently, and doing so with minimal natural and social disturbance. Water education now functions at three levels to impart:

1) *General Knowledge* so that educated people understand the roles of water in nature, society, and the economy; do a better job of husbanding in their personal water uses; and are better informed for bringing the public to consensus on resource management issues.

2) *Technical Knowledge* so that engineers and related specialists know how to design, operate, and maintain facilities (reservoirs, canals, wells, and treatment plants) to benefit the general public and to avoid major environmental and social harms.

3) *Knowledge Building* so that researchers have the background and tools that they can use to solve the puzzles where we find that our knowledge fails us in managing and protecting the quality of our water resources.

The first level teaches everyone; the second launches careers in water resources engineering; and the third trains people for water resources research.

Forces Driving Water Education

A review of the evolution of water knowledge and curricula development reveals three principal motives to satisfy when teaching water resources:

1) *Learning*. The scholar studies to learn because understanding enriches human spirits and establishes a culture of objectivity and precision.

2) *Politics (Theology)*. The social dreamer studies to help mankind. Individuals work hard to convince voters that the projects that they want are justified. In the process of building public support, their justifications tend to be come transformed into "theologies" that believers want taught as water education. The earliest theology was navigation to get farm goods to markets economically. Later theologies were reclamation to give people crowded in urban squalor new lives on formerly non-productive lands; multi-purpose river basin development that efficiently combined electric power, soil conservation, water supply, recreation, etc.; water quality to protect human health; and environmental protection. As proponents were able to establish a theology as "politically correct," objective assessment was forgotten; and resources were spent carelessly until later eras adopted new theologies, often out of the ashes of disdain for what came before.

3) *Self Interest*. Individuals study to satisfy personal needs. Citizens want to get more value from the water

they use, suffer fewer flood losses, and experience less pollution losses. People with a professional bent see career opportunities in water resources and want to learn skills to get jobs.

Ying and Yang

These motives have generated forces that tear educational programs between opposing traditions that have long been argued in a ying-yang dichotomy. The ying is classical and theoretical. The yang is practical and empirical. The ying is puzzle solving, and the yang is problem solving. The followers of the ying are supply driven, and the followers of the yang are demand driven. Engineers see public stupidity, and the public sees insensitive engineers; and this difference in perspective is rooted in inconsistencies in general knowledge.

The greatest need in water education is to rise above fruitless debate to balance these opposites in several dimensions:

1) *Populist v. Elite.* The division of education between training people to make personal decisions and training specialists to make societal decisions; helping people to understand when they would be better off to seek the help of specialists and helping specialists to understand that some management decisions are best made by giving the responsibilities to the people themselves.

2) *Technology v. Science.* The division of effort between research to add basic understanding and technology to apply what we already know to give people better lives; helping water resources engineers better understand the issues when they do not have an objective answer and that they need to turn to science to conduct research.

3) *Majority Favor v. Truth.* The division of education between teaching technical solutions and teaching how to conduct public participation to give people what they want; helping engineers understand public perceptions and helping the public understand the limits to technology.

Developmental Phases

These issues need to be addressed within a moving entity as water education continually changes over time. The goals of water resources management have multiplied and become more difficult to reach as population density has increased, technology has advanced, and people have turned again to environmental values. Measures and means have multiplied as society has used 1) projects to supply human needs, 2) systems of projects coordinated for cost effectiveness, and 3) programs to sustain systems over project life cycles.

The content of water education responds. In overview, water resources engineering first taught hydraulic and structural design to make projects function effectively, added hydrology to quantify flows and natural constraints, and is now probing the limits to environmental and social sustainability. When faced with each new goal, measure, or means, professionals possessed classical knowledge, faced a practical problem, and made professional judgments. However, professionals often see things differently. Over time, the judgments were made consistent by standardizing the methodologies and writing consensus approaches into manuals and computer codes. Thereafter, designs were too often evaluated for their compliance with "accepted practice" as defined by these standards. The need to reassess the reasonableness of the original judgments was forgotten; and, worse yet, water education too often turned from teaching standards and evaluating students on the basis of standardized examinations.

Two Current Issues

The above process has now reached the point of raising serious doubts about the appropriateness of many aspects of the present system of water education. We must search for better ways to teach capacities for thoughtful reflection (science) and innovative creativity (engineering). There are two basic goals:

1) Introducing a dynamics into the process so that education can train people for a practice that keeps abreast of current needs, a way of thinking that learns from the past without making past procedures a straight jacket.

2) Introducing a common base of understanding so that both popular and technical education (and knowledge-building research) are coming from the same facts and headed toward the same goals. We need to create situations where engineers are working with people and the two are not fighting one another.

Nine Themes

The present content of water education was established by identifying what water engineers should know, establishing curricula, and testing young practitioners for licensing. Later political concerns have expanded the necessary common base of understanding to a breadth that technical water education cannot possibly cover.

From this wide spectrum, the body of knowledge to cover in water education draws from many disciplines, and professional training requires courses from many of them. Students are unable to take so much and are left understanding some things at the professional level and other things on the basis of general knowledge. Water educators need to give general knowledge courses on each theme as well as have curricula for professionals.

1) *Engineering.* How to build facilities to function properly. This requires training in hydraulic, structural, and geotechnical engineering.

2) *Hydrology.* How to size facilities. This requires training in science to understand the principles, statistics to analyze frequencies, and a way to assess failures.

3) *Water Quality.* How to protect public health from immediate and long-run threats and protect the natural environment. This requires training in the chemical and biological processes that determine water quality and cause water pollution to have impacts.

4) *Engineering Economy.* How to select from mutually exclusive alternatives. This requires a systematic listing and evaluation of consequences and reduction of the results to a single index of merit.

5) *Economics.* How to use water resources management within a larger program of national economic development. This requires training in the theory of public goods and evaluations of indirect and secondary effects.

6) *Planning.* How to organize a comprehensive examination of all relevant factors in using multiple means to achieve multiple objectives. A primary component was nonstructural measures for demand management.

7) *Systems.* How to reckon with interactions among components and uncertainties. This introduces systems modeling and stochastic analysis.

8) *Environmental Impact.* How to protect natural features in the environment. This introduces the need for cause-and-effect relationships and ecologic modeling.

9) *Social Impact.* How to protect the values that people hold dear. This introduces needs for social relationships and modeling.

Assessment of the Situation

The paradigm used by water resources engineers also has a ying and yang. The planning ideal has been to learn basic principles, define practical problems, collect available information, and select the best alternative objectively. Where quantitative data were limited, professionals learned to make acceptable judgments from basic principles. Teaching how to reason from principles was the ying or the essence of classical water education.

Planning practice, however, has been shifting toward the yang. From this perspective, the current vogue is to prepare, institutionalize, and apply computer models that are programmed to represent legal requirements. People hire engineering firms to make sure that their clients comply with the law, and the firms have their employees run models and compare the results with standards. The system opens the door to permitting people with incomplete training over the above nine areas and with minimal practical experience to find data and infer conclusions by taking models as reality and, worse yet, never realizing that they are not.

In this environment, 1) water education comes under pressure to shift from teaching principles to explaining models, 2) managers equate good planning as running the models correctly, and 3) interest groups that have planning goals are able to create dogma by influencing the standards and models to indicate what they want done before the facts are gathered or analyses performed. At different times, different themes have dominated water resources planning. Society searches for employees trained in currently popular themes and neglects others to its later regret. Water education continually runs the danger of emphasizing trends to the neglect of long-term needs.

Challenges and Recommendations

The major challenge to water education today is to reverse this trend by finding ways to bring agreement between the practical solutions that people want and the natural world as revealed by the study of science. The essence of water education is to train specialists to know enough about all nine themes so that important considerations are brought to public attention and to train the general public to recognize that there are gainers and losers and that a balance must be reached. The knowledge building function of water education must build from this common base. We need a concerted effort to reform the content of water education at both public and specialist levels, to institutionalize a dynamic process to keep what we teach current with what is known, and to give researchers the general understanding that they need for their specialized studies to make solid contributions.

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