
Editor's Message: Hydrogeology education, textbooks and 'Foundations' articles

Vincent E. A. Post

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This editorial is primarily intended as an announcement for a new type of article in *Hydrogeology Journal* termed 'Foundations', which is introduced in this contribution. This editorial is also about the textbooks that we use in hydrogeology. Academics mostly write about their research, and although there are articles about groundwater and hydrology education in the pedagogic literature, it is not often that educational aspects are discussed in "mainstream" research journals, despite the fact that education is intimately related to research, at least within the realms of academia.

Exceptions apply, of course, the most notable being a recent special issue of *Hydrology and Earth System Sciences* titled *Hydrology education in a changing world*. In the introduction to that theme issue, Seibert et al. (2011) identify a number of challenges in hydrology teaching, including the diversity of student backgrounds, as well as finding the right balance between developing deep understanding of basic subjects and multi-disciplinary problem solving skills. Similar views were expressed earlier by Nash et al. (1990), who argued that, in general, hydrology education was not producing professionals with the right background and expertise to study complex, large-scale environmental problems. This latter aspect is also identified by Seibert et al. (2011) as a shortcoming in current textbooks in that they "... do not contain in-depth treatments of how to predict the hydrologic response after changes in climate, degree in urbanization or land cover have occurred, despite the fact that such predictions will be fundamental for future research

and practical hydrological applications". This assertion suggests that our textbooks do not always reflect the latest developments of the scientific field, or fall short in covering the essential set of skills and learning objectives for hydrology students.

A closer inspection of groundwater textbooks seems to reveal that hydrogeology is a well-developed and mature scientific discipline with well-defined core contents. Schwartz and Ibaraki (2001) noted that the landmark Freeze and Cherry (1979) textbook remains authoritative and that groundwater textbooks have long shelf lives compared to those used in other disciplines. The existence of an established consensus about core topics is exemplified by comparing the chapters in the first edition of Todd's (1959) *Ground Water Hydrology* to the third edition by Todd and Mays (2005). The 1959 edition contains the chapters: "Occurrence of ground water, ground water movement", "Ground water and well hydraulics", "Water wells", "Ground water levels and fluctuations", "Quality of ground water", "Basin-wide ground water development", "Surface investigations of ground water", "Subsurface investigations of ground water", "Artificial recharge of ground water", "Sea water intrusion in coastal aquifers", "Legal aspects of ground water", and "Model studies and numerical analysis of ground water". The third edition (Todd and Mays 2005) hardly deviates from this chapter structure: the chapter on legal aspects has disappeared, the modeling chapter has become much more prominent, and a chapter on groundwater pollution has been added. Obviously, the contents of the book have been updated and expanded (the number of pages nearly doubled between the editions), but it appears that in essence, the ideas about what are the basic subjects to be taught to hydrogeology students have not changed much over the past five decades.

Detailed insight into the desired learning objectives of hydrogeology courses follows from a survey among 68 academic hydrogeologists by Gleeson et al. (2012). It was found that there are circa 15 subjects, mainly related to aquifer properties and groundwater flow, that were considered crucial in undergraduate hydrogeology courses by >75 % of hydrogeology instructors. However, in addition to these, there are also over 100 other subjects that some considered crucial. Another survey, conducted by Wagener et al. (2007) among 158 hydrology educators at universities, revealed that no less than 52 different

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Vincent Post is an editor of *Hydrogeology Journal*

V. E. A. Post (✉)
School of the Environment/National Centre for Groundwater
Research and Training,
Flinders University, GPO Box 2100, Adelaide, SA 5001, Australia
e-mail: vincent.post@flinders.edu.au
Tel.: +61-8-82015077
Fax: +61-8-82012676

textbooks were being used, and that teachers found it hard to find a single textbook that completely fulfilled their needs. These studies suggest that, while there appears to be a well-defined core, hydrogeology education comes in many flavors. This is in part due to disciplinary bias (Nash et al. 1990), with hydrology sitting in the curricula of geology, geography, and civil and agricultural engineering, but also stems from a variety of factors such as academic tradition, student and teacher backgrounds, and geographic focus. By some, this lack of a common educational basis is seen as a problem (Wagener et al. 2007), and initiatives are being developed to address it. The MOCHA initiative, for example, strives to develop a freely available hydrology curriculum free of traditional disciplinary biases (Wagener et al. 2012), and the website “Teaching hydrogeology in the 21st century” (Appold 2006) not only offers teaching materials, but also outlines a series of learning goals for undergraduate hydrogeology courses.

Within this education context, *Hydrogeology Journal* will start publishing a new type of review paper called Foundations. The idea was proposed by former editor Philippe Renard. Foundations articles will be on subjects typically encountered in textbooks or taught in (under) graduate courses. The name Foundations was chosen because these subjects form the basis of our science. The aim is to provide a platform that allows fundamental topics to be treated in more detail than what is possible in textbooks. Foundations articles can also clarify common misunderstandings or misconceptions, or provide up to date coverage of a subject that has seen substantial recent developments that are not yet covered in textbooks. The educational aspect is a key characteristic of this article type, and a Foundations article is likely to have a strong methodological focus. While it is not impossible for these articles to report on new research outcomes, they will typically be based on and reference research outcomes published in the literature, at least for the largest part.

This issue of *Hydrogeology Journal* includes the first Foundations article (Post and von Asmuth 2013). This contribution may serve to illustrate the criteria listed in the preceding. The article, on the measurement of hydraulic heads, discusses the underlying concepts of the metric that is fundamental to hydrogeologic science, outlines in much

greater detail than in standard textbooks how it is measured, provides an overview of the latest measurement technology, and discusses the issues associated with measurement procedures. For future Foundations articles, the *Hydrogeology Journal* editors will be actively seeking contributions, but authors are invited to propose subjects for, and outlines of Foundations articles they think are worthwhile by contacting an editor. Hopefully these contributions will be integrated into our teaching and training programs, and will add to the fundamental understanding of hydrogeologic science by students and professionals.

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