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An integrated theoretical and practical approach for teaching hydrogeology

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Hydrogeology as an earth science intersects the broader disciplines of geology, engineering, and environmental studies but it does not overlap fully with any of them. It is focused on its own range of problems and over time has developed a rich variety of methods and approaches.
The resolution of many hydrogeological problems requires knowledge of elements of geology, hydraulics, physics and chemistry; moreover in recent years the knowledge of modelling techniques has become a necessary ability. Successful transfer of all this knowledge to the students depends on the breadth of material taught in courses, the natural skills of the students and any practical experience the students can obtain.

In the Department of Earth and Environmental Sciences of the University of Milano-Bicocca, the teaching of hydrogeology is developed in three inter-related courses: 1) general hydrogeology, 2) applied hydrogeology, 3) groundwater pollution and remediation. The sequence focuses on both groundwater flux and contaminant transport, supplemented by workshops involving case studies and computer labs, which provide the students with practical translation of the theoretical aspects of the science into the world of work.

A second key aspect of the program utilizes the students' skill at learning through online approaches, and this is done through three approaches:
A) by developing the courses on a University e-learning platform that allows the students to download lectures, articles, and teacher comments, and to participate in online forums;
B) by carring out exercises through computer labs where the student analyze and process hydrogeological data by means of different numerical codes, that in turn enable them to manage databases and to perform aquifer test analysis, geostatistical analysis, and flux and transport modelling both in the unsaturated and saturated zone. These exercises are of course preceded by theoretical lectures on codes and software, highlighting their features and their limitations;
C) by an evaluation process whose results contribute to the final examination, so that the students are evaluated on the basis of their ability to discuss theoretical subjects and/or projects and to resolving exercises and case studies either by hand calculations or by modelling.

The applied hydrogeology examination is an example of the evaluation process. It involves development of a plan to resolve a real hydrogeological issue, such as the design of a hydraulic barrier for a landfill, the design of a well field to meet the supply requirements of a muncipality, or the control of possible seepage from a contaminated site close to to sensitive discharge features such as wells, springs, rivers. The students are allowed to work on computers for three consecutive mornings for a total 15 hours, and in the end are required to produce a technical report and a hydrogeological model. Obviously their solutions are neither unique nor completely optimized (just as in the real world), but the comparisons and debates among the students are important portals to learning and improvement.
A second example: the groundwater pollution and remediation examination is based on the discussion of a remediation project elaborated in stages during the course, with the addition of increasing complex types of data and information. The students have one hour a week, during the course, to submit to the teacher their analysis of the problem and possible solutions.

In ten years of experience all students have considered this method of examination a challenge, and found it engaging and helpful, even if unusual, at least in Italy.

The University of Milano Bicocca has recently drilled a piezometric well both to monitor the flow of groundwater

and to allow students to perform aquifer tests and to conduct standard groundwater sampling procedure, without any longer needing to rely on outside private donors for access to a field site.

The overall approach, which includes, lectures, exercises, modelling and applied projects, help the students to consider hydrogeology from various points of view and to gain tools to support the management and protection of groundwater resources.