Workbook of practical exercises in hydrogeology and water resources in an interactive format

Josep Mas-Pla
Albert Folch Sancho

External Geodynamics and Hydrogeology Unit, Department of Geology
Universitat Autònoma de Barcelona

Anna Menció Domingo

Geodynamics area, Department of Environmental Sciences
Universitat de Girona

Abstract

In the field of the earth sciences, cartographic material, databases and numerical calculation methods are presented simultaneously. This workbook of practical exercises on the topic of hydrogeology, developed to be interactive, includes maps, texts, images, databases and spreadsheets aimed at enabling students to better perform the proposed exercises, as they have all the documentation they need in a high-quality format. With the purpose of making it more interesting for students in fields related to hydrogeology and water resources, the exercises were developed using real and up-to-date data and problems in Catalonia, enabling us to capture the complexity of water management in the country and assess both its potential and its limitations.

General area of interest of this innovation

This project is targeted to students who aim to interpret hydrological concepts based on real problems. It is organised into a general syllabus in the area of hydrogeology, so that the simpler cartography or data interpretation problems (those from an introductory course) can be resolved with their corresponding calculations by using real data, with all the added value this entails.

1. Objectives

Meaningful learning at universities is facilitated when the contents are interrelated and organised around each other, in addition to when they have points in common with students' past experiences. Along these lines, if activities are planned that start from

what the students already know and with experiments that require both physical and intellectual activity, this contributes to producing meaningful learning. Furthermore, if students are also given activities that require them to apply what they have learned in new situations, this will foster relevant learning (Murillo, 2003).

To this end, the material targeted at classroom problems or practices is a crucial cornerstone for students to grasp the theoretical concepts taught in the theoretical classes, and at the same to for them to learn conceptual and procedural contents that can hardly be acquired without performing practical activities. In courses that deal with the physical environment, such as the earth sciences, a gradual explanation of the concept — from both the theoretical and the practical perspective — is needed, plus it is absolutely essential that they be identified and assessed in the field where real problems exist. Specifically, the hydrogeological aspects that are dealt with in this proposal are an important vector in the field of applied and environmental geology. Given the importance of water resources in the day-to-day management of the environment, an issue that is subjected to political purposes which often have poor scientific and objective underpinnings (in reference to certain aspects of the National Hydrological Plan approved in 2001, as well as other debates on water conveyance), proposing study tasks with real cases and data enables students to also gain awareness of and shape their attitudes towards these problems.

Therefore, in the case of the disciplines related to water resources, the three-phase teaching schema (concept, classroom/laboratory practice and field experiment) is valid and should be used in the curriculum. Nevertheless, for a variety of reasons, field practices in themselves are insufficient and provide neither a comprehensive perspective nor enough experience to train future professionals, whether they be geologists, environmentalists or land engineers. For this reason, we must often replace field experience with classroom practices in which the use of a range of media —— maps, graphs, photographs, data tables and calculation tools— is indispensable. This diversity of material requires complex, exhaustive preparation, which is not very common.

The goal of this project was to draw up a workbook of practices in the field of hydrogeology and water resources that would include all the teaching materials students would need to properly grasp the problem or practice to be resolved, and that would simultaneously include practical aspects that are geographically relevant to the students: in our case, about Catalonia.

In view of the different formats of the materials needed –maps, texts, databases and spreadsheets– the most convenient way of drawing up a workbook of practical exercises was by computer, which would make possible interactive access to the different levels of information and working tools. Planning this workbook as a «website», then, was the most appropriate way to resolve the practice and ultimately ensure that students comprehend and learn the material the best.

2. Description of the project

2.1. Methodology of the workbook

In order to achieve the goals set forth above, the following methodologies were used:

1. Choosing the main concepts that appear in the guidelines for the curricula in Geological Sciences and Environmental Sciences for the students to whom this workbook is targeted, and then developing a set of exercises that enable students to conceptually grasp and resolve real problems within the geographic setting of Catalonia.
2. To draw up a series of conceptual problems that enable students to understand and delve further into the theoretical concept.
3. To document the exercises with maps, images, data and all the supplementary information needed for proper learning to take place. To prepare spreadsheets in MS Excel that help students resolve certain problems.
4. To use computers, in the form of a website (html format) as the best way to present the material so that students can interact with all the documentation they might need to resolve the exercises.

3. Results

The contents of the project in its final phase consisted of a compendium of exercises in a website which constituted the Workbook of Practical Exercises on Hydrogeology. This web-based environment is broken down into the following sections, which are reached from an initial portal:

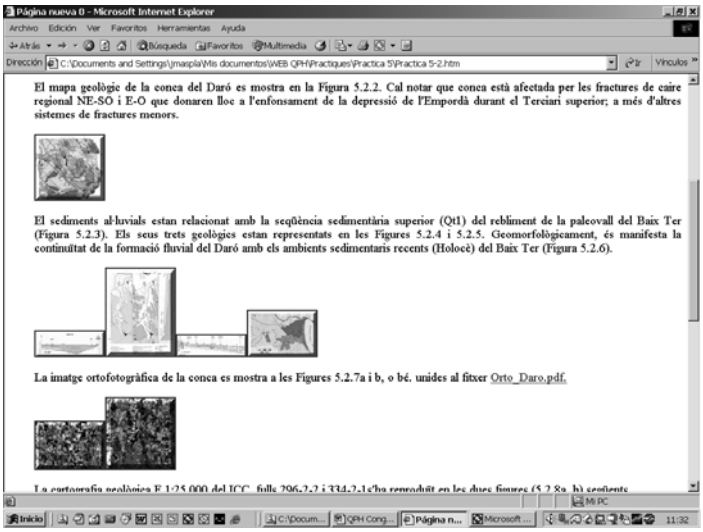
1. Introduction to the workbook: Purposes, goals and contents.
2. Practical exercises: A total of six topics developed as the syllabus (Figure 1):
   a) Introduction to water resources in Catalonia
   b) The hydrological cycle and the water balance
   c) Infiltration
   d) Surface hydrology
   e) Aquifers and geology
   f) Hydrogeology: Piezometry
   g) Hydrogeology: Catchment
   h) Seawater intrusion
   i) Hydrochemistry
   j) Transport of solutes in subterranean waters.
3. Glossary: A definition of the most important geological terms that appear in the practices and their translation into English.
4. Bibliography: References to the most important reference books as well as maps, articles and laws.
5. Links: Electronic addresses of state and international websites in the field of hydrogeology.

In terms of the website format, this format offers the following possibilities, which can be divided into the strong and weak points of this teaching proposal:

3.1. Strong points

- The possibility of accessing any part of the general contents from the homepage or any of the sections.
- Each practice includes a brief theoretical explanation, a selection of problems and the exercises based on the real hydrogeological properties of Catalonia. From each part, users may interactively access figure, maps, orthophotomaps, text documents, databases and templates in MS Excel. Figure 1 shows an example of how the images/maps are presented, which users can then expand or copy.

Figure 1. Example of a map query



- All the databases and spreadsheet templates are in MS Excel, so they are easy to use. The templates enable users to see the programming used in the different cells to solve numerical problems. These templates are appropriate for making routine calculations such as the real and potential evapotranspiration (Thornthwaite method), studying maximum flow using the Gumbel method, analysing standard pump tests, representing hydrochemical graphs and resolving equations on the transport of pollutants, among others.

- There are links to other websites that might be interesting for getting more data or expanding on certain aspects of the problem.
- The real databases for a given exercise help students to do a practice with cases that are geographically more familiar to them and therefore more engaging. One example is the study of the flows of the Ebro river in light of the proposals set forth in the 2001 National Hydrological Plan.
- Having more comprehensive material enables students to learn more about the subject of the exercise and therefore increase the total time they spend on the individual work.
- The students have favourably rated the possibility of connecting to selected websites related to the subject and the savings on costs on photocopying that this has entailed.

3.2. Weak points

- Some types of materials are difficult to check. Specifically, the exercises only contain fragments of the maps that need to be checked, which were previously scanned from the paper publications. This makes it impossible to check the entire map and, more importantly, its legend. In this sense, the general opinion is that having the information digitalised is a step forward compared to having to share a paper map among several students, although perhaps keeping one copy of the original map in the school library to be checked is also a good idea. The use of the cartographic resources (topography, orthophotoimages and geological map) from the Cartographic Institute of Catalonia (website: http://www.icc.cat) makes this task easier, despite the fact that the legends are always more extensive on the paper maps, especially geological maps at a scale of 1:25,000 which are not available interactively.
- The use of real data was appealing, although in some cases it meant an added difficulty given the fact that they represented more complex hydrogeological behaviours and dynamics than the kind found in the synthetic cases that usually appear in textbooks. In this sense, the general opinion is that solving generic problems in the classroom with a teacher's guidance before analysing real cases is both necessary and profitable.

With regard to the time students spent on individual work, completing all the exercises contained in the workshop required more hours than if the credits for the course were evaluated according to the ECTS calculations. In this sense, a hierarchy of exercises and problems should be set at the teacher's discretion, such as between obligatory and optional exercises, according to the length of the course and the most important topics to be covered.

4. Conclusions

Developing the Workbook of Practical Exercises on Hydrogeology has made it easier to integrate all the documentation needed to resolve practical exercises on this topic, bringing classroom practice closer to reality. The effort to complement maps and orthophotoimages is reflected in students' heightened grasp of the hydrogeological problem, which enhances their training.

The experience enabled us to assess the strong and weak points of the teaching proposal, concluding that it is useful as an efficient individual work tool that is appropriate for distance learning.

References

DOMÉNECH, F. (1999). «El diseño de instrucción». In DOMÉNECH, F. (ed.). *Proceso de enseñanza/aprendizaje universitario*. Universitas, pp. 63-94.

LÓPEZ, F. (2005). «Cómo desarrollar clases participativas: claves para el éxito». In *Metodología participativa en la enseñanza universitaria*. Madrid. Narcea. Chapter 7, pp. 125-149.

MURILLO, P. (2003). «Formas de entender el aprendizaje de los estudiantes universitarios: teorías y modelos de aprendizaje adulto». In C. MAYOR RUIZ and C. MARCELO (Eds.). *Enseñanza y aprendizaje en la educación superior*. Barcelona. Octaedro-EUB, pp. 49-82.

Keywords

Hydrogeology, water resources, interactive format, new technologies.

Financing

This project was financed via a project to improve the quality of teaching at universities in Catalonia (MQD 2003, Resolution UNI/135/2002 dated the 19th of April 2002, Official State Gazette no. 3628 - 03/05/2002) from the Department of Universities, Research and the Information Society of the Generalitat de Catalunya, and by aid from the UAB 2004 Convocation for teaching innovation projects.

Supplementary materials on the CD-ROM

Demonstration of content of an interactive Hydrology field notebook and virtual tour of the practical components of the subject (includes maps, data bases, etc.).

Project leader

Josep Mas-Pla
Area of Geodynamics
Department of Environmental Sciences
Faculty of Sciences

Universitat de Girona,
Montilivi campus
17071 Girona
josep.mas@udg.edu

Presentation of the working group

The working group on innovation in research into hydrogeology is made up of the professors teaching this course at two universities, UAB and UdG. They teach courses on this subject in the Bachelor's in Environmental Sciences and the Master's programmes at both universities. Their research focuses on different aspects of hydrogeological dynamics and their environmental repercussions, from which part of the data compiled in the workbook of practical exercises was taken.

Members of the project

Anna Menció Domingo
Area of Geodynamics
Department of Environmental Sciences
Faculty of Sciences
Universitat de Girona
anna.mencio@udg.edu

Albert Folch Sancho
External Geodynamics and Hydrogeology Unit
Department of Geology
Faculty of Sciences
Universitat Autònoma de Barcelona
albert.folch@uab.cat