A learning resource to support Masters-level training of geologists in professional practice

Norman Moles, Rory Mortimore and Andrew Thrower,

School of the Environment, University of Brighton

Abstract

Postgraduate-level training in 'professional practice' is essential to enable students (a) to understand business management and the role of geologists, civil engineers and environmental scientists in industry, and (b) to advance their skills in report writing, oral presentation, negotiation and financial acumen. This is best achieved through exposure to 'real world' case study material. With GEES Subject Centre support we are developing a multi-media learning resource for students to explore the interactions between environmental legislation, corporate strategy, financial constraints, geotechnical engineering and applied geology. Our case study is an investigation of wastewater treatment by means of sub-surface dispersion within a Chalk aquifer in southern England. We have evaluated the course with groups of students on final year undergraduate and Masters level geology courses. Issues include achieving a suitable balance between individual and group work, between scientific understanding and professional skills development, and between specialist knowledge and transferability to other GEES disciplines.

What is 'professional practice' and why is it important?

Science and engineering degree programmes are primarily designed to develop scientific or technical understanding of the discipline. Unless students were fortunate in securing arelevant work placement or industry-based employment during a vacation, they may have graduated without being exposed to a professional working environment. Many graduates are unfamiliar with the role played by geologists, civil engineers and environmental scientists in industry and in government agencies. The phrase 'professional practice' embodies this experience and skill set. Familiarity with professional practice should increase students' employability and assist their transition from a graduate student to a practising geoscientist or geo-technician.

A case study approach is arguably the best way to bridge the gap between scholarly activity and the work place. Case studies based on 'real' industry projects in a 'virtual learning environment' can recreate the immediacy and complexity of working in industry, where decisions are frequently based on incomplete evidence. Skills in decision making are enhanced by taking on ownership of the project, and being closely involved in the decisions made at all stages of project development. By drafting work briefs, evaluating bids for drilling contracts, and logging borehole core recovered from site investigations, students directly experience issues such as quality assurance that are faced by professional geologists. This approach also provides students with opportunities within their modular work or dissertations to contribute to real scientific projects relevant to their future careers. As noted by Healey et al. (2003) and McQueen (2003), research-informed teaching is probably common in the Earth Sciences but hitherto has not featured extensively in pedagogical journals.

Professional practice in the Applied Geology MSc programme at Brighton

The context to this article is a one-year MSc taught course in Applied Geology at the University of Brighton. Brighton has a long history of geology teaching within civil engineering courses and the module title 'Geoframeworks' is intended to convey the dominant theme of the Masters course, namely the integration of geological science and engineering practice (Moles & Mortimore, 2003). One of us had previously developed a professional practice module within the final year of a BSc Geology course (Moles & Leslie, 2000). Since 2002 we have developed a 'Professional Practice' module that is appropriate to the skill-level of Masters students and builds on the environmental and civil engineering focus of the Applied Geology programme. The module involves students in the evaluation of an industry-based geotechnical / geochemical investigation of wastewater treatment by means of sub-surface dispersion within a Chalk aquifer. The overall aims are to:

- Introduce the roles of and links between scientists and engineers in industry and government
- Highlight the influence of legislation and corporate strategy on site investigations
- Show how technical data are obtained and how its quality is managed
- Encourage decision-making based on incomplete evidence
- Develop presentational, reporting and negotiating skills in an industry context

One problem with the case study approach is the difficulty in retaining supporting material for long-term use. This can be due to the ephemeral nature of telephone conversations and email exchanges, the loss of physical evidence such as drill core, and indeed the loss (or promotion!) of key staff. To combat this problem, and with support from the GEES Subject Centre Small Projects programme in 2003-04, we have created a multi-media 'learning resource' entitled 'Professional practice of Earth scientists in industry'. The idea was to capture onto computer media a range of documents including minutes of meetings, work specifications, reports, drill logs, site maps and images, together with audio files of interviews with personnel involved at various stages of a specific investigation. After an introduction to the case study, courseware users are encouraged to explore the material to answer questions such as the objectives and driving forces of the investigation, the management structure and responsibilities of personnel, and how professional standards such as quality assurance and health and safety are maintained.

Courseware platform

Having researched software options we chose the application Macromedia Flash Professional 2004. This software enables audio and video recordings to be integrated with text and graphics in Powerpoint-style slides. Loops and links can be programmed more readily than in Powerpoint. Flash allows frame-by-frame editing and insertion of subtitles in video clips. It enables interactivity and feedback from formative exercises, and control of access and progression through the courseware. Some problems arose with compatibility, as running the software from disc requires Flash Player 7 which is not universally available on university PCs. Memory overload from the embedded video clips also caused operational problems. These issues have been resolved through use of Sorenson's video compression software and delivery of the courseware using the broadband capabilities of the Blackboard intranet provision (named studentcentral at the University of Brighton).

Wallisdown case study

Our case study is based on recent investigations by Southern Water plc of a number of their aquifer-discharge water treatment works (WwTWs). These investigations aimed to delineate subsurface water flow and water chemistry to ascertain the sustainability of this method of wastewater treatment. A University of Brighton team was contracted by Southern Water to log core, extract pore-water for chemical analyses, and compile reports on several of the WwTWs.

For the purpose of the MSc course, the company asked that we avoid referring to a specific site and we named our imaginary location Wallisdown. This WwTW is located in an open valley a few kilometres from a village. Land uses include farmland, woodland - in part a nature reserve - and a golf course. These points are important to the project, since before the (virtual) intrusive investigations begin, students must consider the topography and hydrogeological regime, plan borehole locations with due regard to environmental impact, and negotiate access to the land (Figure 1). At a mock Public Relations meeting, students role play Wallisdown landowners, residents, business people and action groups, who want to know (in layman's terms) the company's plans and what impact they will have. Those students role-playing the company personnel quickly realise that negotiation skills are vital for the company's success.

Elsewhere in the module, role play is used for summative assessment (Tables 1 and 2). In Phase 2, students adopt the role of contractors and bid competitively for the drilling contract, while tutors role-play the company project team evaluating the

Table 1. Courseware structure and content with links to formative and summative exercises.

Section	Main heading	Sub-headings
Course introduction	Course aims and outcomes	Background, course objectives, learning outcomes, methods of assessment
	Professional codes	Why are codes of conduct needed? Examples
Phase 1: Project context	Introduction to aquifer characteristics and groundwater flow	Aquifer structures, groundwater flow models, chemical and microbial processes in groundwater
	What happens in an aquifer-discharge water treatment works	Virtual tour of an aquifer-discharge WwTW
	Legislation and controls on groundwater quality	EU and UK water legislation, occurrence and health hazards of listed substances
	Corporate strategy and business management	Water industry regulators, business management procedures
Phase 2: Project instigation and contracting	Introduction to Wallisdown WwTW	Site history, geographical setting, geology, hydrology and hydrogeology
	Investigation methods	Surface geophysical methods, borehole monitoring, borehole drilling techniques, equipment guidelines
	The tender and bid process	Clients and contractors, competitive tendering, selective tendering, nomination
	The Work Brief	Work Brief requirements, layout, good and bad practice, contingencies
	Bid assessment and contractor selection	Criteria, preference weighting, scoring bids
	Assessed exercise: bid for the Wallisdown drilling contract	Video clips of presentations with commentary on content and style
Phase 3: Construction	Wallisdown geological and hydrological baseline data	Stratigraphy, geological structure, monitoring well piezіometric data
	Borehole configuration and depth	Ideal borehole configurations, geological constraints, geotechnical constraints, work sequencing
	Assessed exercise: optimizing borehole locations at Wallisdown	Interactive maps, cross sections
	Construction work good practice	Preliminaries, health and safety issues, operational logistics, waste disposal, borehole completion
	Land access and public relations	Land ownership, interest groups, negotiating compensation, good practice in public relations
	Formative exercise: PR meeting at Wallisdown Village Hall (role play)	Managing a public meeting, strategies for success (and failure), legal position
Phase 4: Data acquisition and quality assurance	Core recovery and transportation	QA issues: contamination, sample loss, core damage
	Core logging	Video: logging procedures, lithologies, fractures, engineering grade
	Assessed exercise: geological and geotechnical logging of borehole core	Guidelines for geotechnical logging, TCR, SCR, RQD and grade classification
	Pore water extraction	Centrifuge extraction design, optimizing parameters, safety, quality assurance
	Data integration and synthesis	Pore water chemistry data, data quality, integrating core log and water chemistry data
Reporting and evaluation	*Assessed exercise: Project report and oral presentation*	Purpose of the report, scope and division of tasks, length and layout, advice for the oral presentation, assessment criteria
	Evaluation of learning outcomes	Students' (and tutors') reflection and feedback

Table 2. Tasks and mark allocation for summative assessment of the module.

Task (Phase)	Individual or team work	Weighting
3-page report and 5 minute oral presentation for a drilling contract bid (Phase 2)	individual	20%
1-page report proposing and justifying a borehole configuration (Phase 3)	individual	15%
Log of drill core (actual core or photographs) showing stratigraphy and engineering grades (Phase 4)	team	15%
Final report comprising a project completion appraisal and a team-delivered oral presentation of 20-25 minutes duration	compiled by team with individual contributions identified	Report 25% Oral 25%
	Individual total:	60%
	Teamwork total:	40%

bids. Students learn how tendering and contractor selection operates in practice. Preparing the presentations reinforces students' understanding of investigation methods, drilling equipment and costing, and tutor feedback aims to build their skill in oral presentations before they undertake their final report presentation. The scenario for the final report is an end-of-project evaluation by the company team, for which they have to allocate tasks equably. Tutors role-play senior management in assessing the team presentations.

Learning outcomes and assessment

The Professional Practice module specifies the following learning outcomes:

- an awareness of the legislative and corporate forces that drive engineering and environmental geology investigations
- knowledge of project management processes particularly the design of work briefs and contracting
- a sound knowledge of the procedures used in undertaking a geologically-oriented site investigation including a drilling programme
- an understanding of quality assurance and health and safety issues in industry
- skills in preparing business-type reports and delivering oral presentations, which may be based on team investigations

Formative assessment is mostly built into the courseware in the form of interactive exercises that test understanding of topics covered in each phase. The format of the exercises varies; some are true/false or multiple-choice questions, others require diagrams to be appropriately labelled or items to be ranked in an appropriate order. Progression from one phase to the next requires completion of the exercises to obtain a 'password' allowing access to the next phase. Tutor feedback on the individual and group work exercises associated with Phases 2, 3 and 4 (Table 1) also contributes to formative assessment. Summative assessment as applied at the University of Brighton is shown in Table 2.

Student feedback

During 2004 the Professional Practice module was run with two groups of Brighton students, those taking the MSc Applied Geology course and final year undergraduates on the BSc Geology programme. For the MSc students the module was run in the conventional 'long thin' mode with a 1-hour contact session each week for 10 weeks followed by independent study and presentation of reports. The undergraduate students were provided with a 5-day intensive course ('short fat' mode) in the second semester following submission of their final year project dissertations.

Students' responses were generally very positive and showed that the learning objectives had been met. Asked what they had gained from the module, students listed:

- Improved skills in oral presentation
- Ability to work under pressure
- Working effectively as part of a team
- Learning new skills of negotiation and logistics (land ownership issues etc.)
- Understanding the importance of legislation and company structures
- A better understanding of how large site investigations are undertaken

Asked what they regarded as the three best features of the module, students said:

- Group work, spending time with classmates
- Oral presentations (other students listed this as one of the worst features!)
- The core logging exercise (this involved teamwork with a set time constraint)
- Learning how professional practice interfaces with geology
- Feedback from the tutor on presentations and exercises (to help meet the learning objectives, students were given immediate feedback from tutors on their performance)

Offering the same module to students on the BSc and MSc courses is not a sustainable situation, as in future years Brighton-based BSc students will progress onto the MSc course. We are considering the development of a different topic for the BSc 'professional practice' module, or merging it with an existing module on the geology of major civil engineering projects.

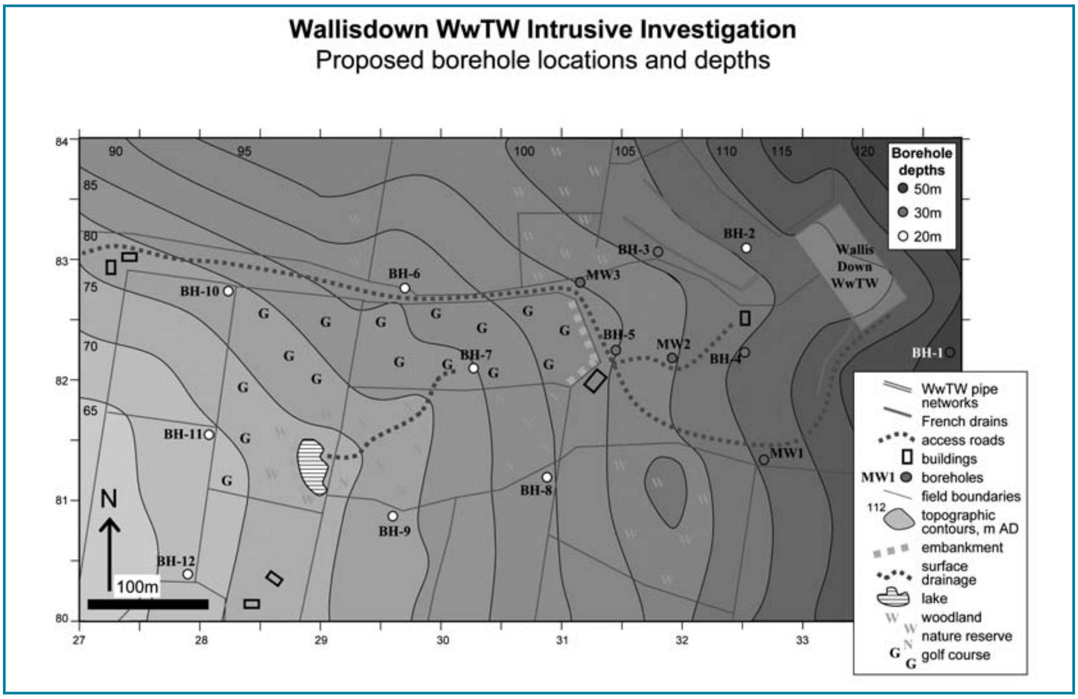

Figure 1. The Wallisdown Wastewater Treatment Works - proposed borehole locations and depths

Issues and lessons learnt

The MSc students were not subjected to the same time constraints and work pressure experienced by the undergraduate cohort. An intensive ('short fat') course format simulates realistic work pressures, encourages effective teamwork and focuses attention, and students gain immense satisfaction from completing the course. Avoiding overlap with concurrent 'long thin' modules can be difficult, particularly where students take optional modules outside the main subject area. Students often have part-time employment or other commitments such as child care which clash with an intensive course schedule. This format is also a greater problem if students are unwell or cannot attend for other reasons. In 2005 we plan to trial the MSc module with a blend of the two formats, i.e. weekly tutorials interspersed with periods of intensive work.

Two aspects of the course approach – teamwork and oral presentations – created student anxiety, as has been noted by others (e.g. Whalley and Favis-Mortlock, 2003). Students commented that they would have been less anxious about giving oral presentations if there had been more of such exercises throughout their course. A recurring issue in PBL-type courses is achieving a suitable balance between individual and group work. We have pitched the assessment balance at 60:40 individual:team work but seek opinions on this choice. In developing the course we were also faced with the issues of balancing scientific and technical content with professional skills development, and with transferability to other GEES disciplines. Geology graduates found the introductory material on aquifer characteristics too simplistic, whereas this material may be challenging for other graduates. Both sets of students asked for more geological data on the case study area. While more has been incorporated in the courseware, we need to explain that an essential feature of the module is to require decision-making based on incomplete data.

Conclusions and recommendations

Developing a CBL resource requires a significant investment of staff time, which in this case, had to be juggled with other academic commitments. However this exercise has encouraged us to expand the content and range of material in the module in addition to creating a courseware product. 'Professional Practice' started as an optional 10-credit module in the MSc Applied Geology course, but is now the main component of a 20-credit core module on 'Geoframeworks'.

From summer 2005 the courseware will be available on-line via a video-streaming server to users at other universities in the GEES network. It may be used either as a stand-alone module contributing 10 to 20 CATS points towards an MSc degree programme, or as a primer for further independent studies of professional practice in industry. Tutor guidelines will be provided in web-page format separately from the student learning resource. The courseware is designed primarily for those who have graduated in the GEES subject area, however most of the content is not technically challenging, and graduates of other disciplines or final year undergraduates should be able to understand the material. In addition to video material, photographs and graphics are included in the courseware and a glossary of terms and references to reading materials are provided.

In due course we hope that readers will review our courseware and provide suggestions for further developments. A demonstration extract will be available on the University of Brighton School of the Environment website. We hope that with GEES support, authors of PBL-type courseware designed for Masters level courses at other universities will also make such courseware available on-line for use outside their home institution.

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Norman Moles, School of the Environment, University of Brighton.
Email: n.moles@brighton.ac.uk