Should fieldwork be compulsory in Hydraulic Engineering courses?

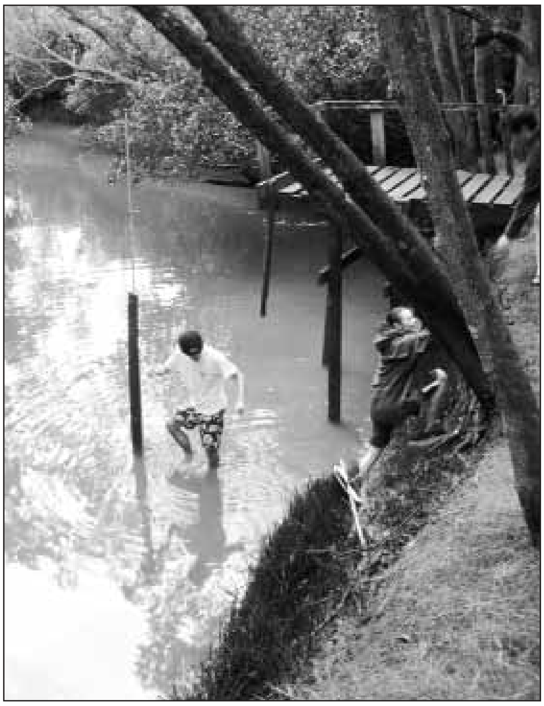
This article derives from a presentation at the 2003 IAHR Biennial Congress in Thessaloniki, Greece. A fuller version was published in the ASCE Journal of Professional Issues in Engineering Education and Practice (2004).

Engineering graduates should be familiar with real-world problems, practical applications and relevant solutions. Hydraulic engineers are no exception, but the teaching of open channel hydraulics is a major challenge. In open channel flows, the free surface rises and falls in response to perturbations to the flow (e.g., changes in channel slope or width). The location of the free surface is unknown beforehand. The main parameters of a hydraulic study are the geometry of the channel, the properties of the flowing fluid and the flow parameters. Flow calculations are non linear, often iterative, and not always intuitive.

In Australia water supply is limited because of the dry climate, and water engineering expertise is critical to the continent's future developments. Therefore most undergraduate civil and environmental engineering curricula in Australian universities include a significant hydraulics component. At the University of Queensland, hydraulics and water resources engineering are taught within the civil and environmental engineering curricula which deliver, respectively, about 80-140 and 5-20 new graduates each year. Following a common first year for all engineering degrees, the students are taught hydraulic engineering in a series of compulsory and elective subjects which are mostly common to civil and environmental engineering students. Compulsory subjects include hydrology in the second year, fluid mechanics and open channel flows in the third year and a component of civil design in the fourth year. Elective subjects are typically taught in the fourth year. Each subject corresponds to two units within the engineering curriculum of 64 units over 4 years. With over 33,000 students, the University of Queensland is the largest and oldest university in the State of Queensland. Although perhaps not strictly characterised as an average university, its undergraduate civil engineering curriculum is representative of Australian civil engineering curricula - with a broad-based course and a strong focus on water resources.

Pedagogy of the Hydraulic Engineering Course

In the context of undergraduate subjects, design applications in the classroom are restricted to simple flow situations and boundary conditions for which the basic equations can be solved analytically or with simple models. Field work activities are essential to illustrate real professional situations, and the complex interactions between all engineering and non-engineering constraints. For example, a storm waterway design requires a hydrological study of the stream to estimate the design flow rate and to predict the risks of emergency conditions. The dimensions are based on hydraulic, geotechnical and structural considerations, and the impact of the waterway on the environment must be taken into account as, for example, in flooding of the upstream plain, and tailwater conditions.



Fieldwork in 2004 as part of an advanced hydraulics class - Students conducting fish and water quality sampling in a subtropical estuarine zone at low tide in Queensland.

Although first introduced to motivate students' interest, field studies in undergraduate hydraulic courses have been an integral part of the teaching pedagogy for more than ten years at the University of Queensland. The field work assessment component typically ranges from 5 to 30% of the overall assessment. Importantly, it adds some personal experience to the teaching. How many professionals have walked on a fully-silted reservoir, counted endangered wildlife species (e.g. koalas, and swamp wallabies), recorded water quality parameters and fish habitat characteristics ? Many will never feel such real-life context, but this experience can be enlightening under expert guidance as part of an undergraduate's studies.

Selection of field trips

A careful selection of field trip sites is essential to maximise learning. A proper balance between successful structures and failures is important. The writer's experience suggests that successful design sites are as important as failure sites. Everyone can learn from a failed structure, although it takes some research to comprehend all aspects of the causes of failures. But it takes a well-trained professional to emphasise the key details of a successful design. Why was this design successful ? What could have been wrong ? How ?

The writer has organised undergraduate field works in hydraulic engineering for more than 10 years involving more than 1,000 undergraduate students. The adjoining figure shows Advanced Hydraulics students conducting an ecological assessment of the estuarine zone of a small subtropical creek. For 12 hours, students surveyed hydrodynamics, water quality parameters, fish populations, bird behaviours and wildlife sightings at three sites. They concluded their works with a group report and an oral presentation in front of student peers, lecturers, professionals and local community groups.

Survey results

Feedback was sought in a survey of the role of field works in the undergraduate teaching

of hydraulic engineering. Advice was sought from students, recent graduates, senior professionals and employers in Civil/Environmental engineering.
Anonymous student feedback was collected at the end of four field studies performed in 2002 and 2003 in two compulsory subjects: Open channel flow and Civil Design, and two elective subjects: Advanced hydraulics and Mixing in rivers. Although feedback was anonymous and not compulsory, more than 70% of the classes answered.

The results demonstrate that students considered field works as an essential component of the hydraulic engineering courses and an important aspect of their civil/environmental engineering curriculum as shown in the adjoining bar chart. 78% of the students believed strongly or very-strongly that "*fieldwork was an important component of the subject*". The survey results showed that students perceived a clear difference between a construction site visit, the investigation of a hydraulic structure in operation (or disused) and a hands-on field study. Fieldwork encouraged strong group bonding as it is well-suited to group work, allowing students to gain better in-depth understanding of professional teamwork and designs. Although the students believed that field studies did not replace traditional lectures, a large majority felt that field experience helped them to think more critically about hydraulic engineering. 96% of the students believed that fieldwork plays "*a vital role in comprehending real-world engineering*"

Anonymous results highlighted that field studies were not self-learning nor self-paced. For example, nearly half of the students did not agree strongly or very-strongly that field studies were self-paced. Students needed expert guidance and knowledge to comprehend all aspects of a prototype design. For example, 80% of students welcomed strongly and very-strongly on-site guidance. In a few instances, some students conducted field works individually. The outcome was disappointing. Their reports indicating that they learnt little and missed vital issues. The writer interviewed students who conducted both supervised and unsupervised fieldwork for the same course. A general observation was that students involved in unsupervised studies did not learn to think more critically. Most students regarded expert supervision a necessity to gain first-hand knowledge that may be emphasised by an enthusiastic lecturer. This aspect was particularly important during multi-disciplinary field studies. For example, during the environmental and ecological assessment of a creek (see the figure), academics from the Department of Zoology at UQ, professionals from the Environmental Protection Agency (EPA)and local wildlife experts were involved and interacted with the students during the field study. The same experts were also involved in the assessment process.

Handwritten and verbal student comments added some personal feedback highlighting a strong student motivation for hydraulic courses associated with fieldwork. Field trips helped the students to visualise professional situations. They motivated them much more than conventional lectures and audio-visual aids, even laboratory works. Fieldwork offers students some professional exposure and involves prototype dimensions. For example, students in the Open channel flow course conduct both field studies and laboratory works. But the laboratory culvert experiment does not have the fascination of a prototype structure: "*This is the real stuff*", "*nothing can beat the real-world* [experience]", "*awesome, breathtaking*" (Students' comments). For example, in a real storm waterway canal, students can walk along the entire structure. They feel the flood waters rushing down the canal and can imagine the consequences of an incorrect design. Students expressed clearly a greater motivation for hands-on experience in the real world under academic supervision.

This increased interest for the course translated always in higher marks in coursework and examination papers, and, more importantly, a lower failure rate in these subjects. Prior to the introduction of fieldwork, the failure rate in hydraulics subjects was about 15 to 30% ,on average, over a ten year period. Since the introduction of fieldwork, the failure rate in the same subjects, has reduced significantly. This trend was best noted during the two first years after fieldwork was introduced because the curriculum remained unchanged and examinations were similar. On average, over the first four years following the introduction of fieldwork, the failure rate in these hydraulics subjects was 10.6% (standard deviation: 7.2%). Since then the failure rate has ranged between 5 and 22%.

The impact of fieldwork on students' performance was mostly noticeable in the "tail" of the class: i.e., the students with low grade point averages. Failure rates among the weakest students were reduced by nearly 70%. In several instances, individuals were noted to "switch on" during fieldwork and students commented included: "*I gained interest for the civil engineering course thanks to the real stuff (field studies)*", "*fieldwork is great stuff*"; "*why don't all lecturers bring us in the field?*"

Professional feedback
In addition, the writer interviewed a number of former students: i.e., civil and environmental engineering graduates with less than 5 years experience. For a sample of over 40 young graduates, 95% had a vivid memory of the field trips in hydraulics; 90% believed strongly or very-strongly that field studies were an important part of the curriculum. Most believed that fieldwork experience helped them in their career development.

The writer further interviewed a number of civil engineering employers, including government departments, private consultants, and mining and construction companies. From a sample of more than 25 senior engineers, managing directors and CEOs, all stressed that field experience, including fieldwork under academic supervision, was a basic requirement for civil engineering graduates. This was often associated with strong in-kind support to assist and facilitate field studies. For example, during the field study shown in the figure, the EPA contributed with more than 25 man-hours and launched a boat on the study day, local communities contributed more than 50 man-hours, and equipment was lent by several academic, government and local institutions.
During discussions with leading engineers, some employers were shocked to learn that fieldwork was no longer compulsory in undergraduate civil engineering curricula. The response suggested that senior professionals placed more emphasis on hands-on experience rather than "virtual" education.

Discussion
Anonymous feedback and discussions with students highlighted the importance of appropriate on-site guidance and expertise, associated with enthusiastic lecturers. Students can become thrilled by relevant

field studies directly relevant to the course material. For example, a culvert is often perceived as a “dull” structure in the classroom, but it may become a fascinating hydraulic structure in the context of a hydraulics field work, particularly with large structures. From experience, the selection of field study sites must be changed from year to year. The weak students who failed the subject in the previous year must be given the opportunity to learn more and be involved in a new field activity.

Personal experiences

A key outcome of fieldwork is the personal experience gained by students. While this aspect is hardly quantifiable and often ignored by university management, there is no doubt that field studies can enhance a student’s individual experience and personal development. The writer has experienced this first-hand, and received considerable individual feedback. For example, an international student was very surprised to see a koala walking right in front of her during an ecological survey; a former army personnel involved in fish sampling said : “*I did not believe that I would ever use survival skills in an engineering course*”; a first-class honours female student discovered the intricacies of practical works in harsh subtropical conditions with no freshwater nor toilets on site; she added “*it was more a matter to mix with the environment than to study river mixing*”. Students are not the only ones to learn : e.g., a Japanese visiting academic met face to face a swamp wallaby (small kangaroo) at sunrise.

Group work contributes to new friendships and openings: e.g., between civil and environmental students, between Australian and international students, between students and professionals involved in the study. Such personal experiences are at least as important as the academic experience.

While introductory field studies are simple, advanced fieldwork may sometimes be feared by students. The writer can mention cases of students who were apprehensive about the field experience prior to the activities. For example, fish sampling, work in snake-infested areas, wildlife surveys are not always perceived a “fun” activity. Yet all the students had the courage to take on the challenges and the writer has not experienced a single failure. Discussions with students after the field activities demonstrated that some learned to control their fears and all had a great experience. Group field works are particularly well-suited to anxious students.

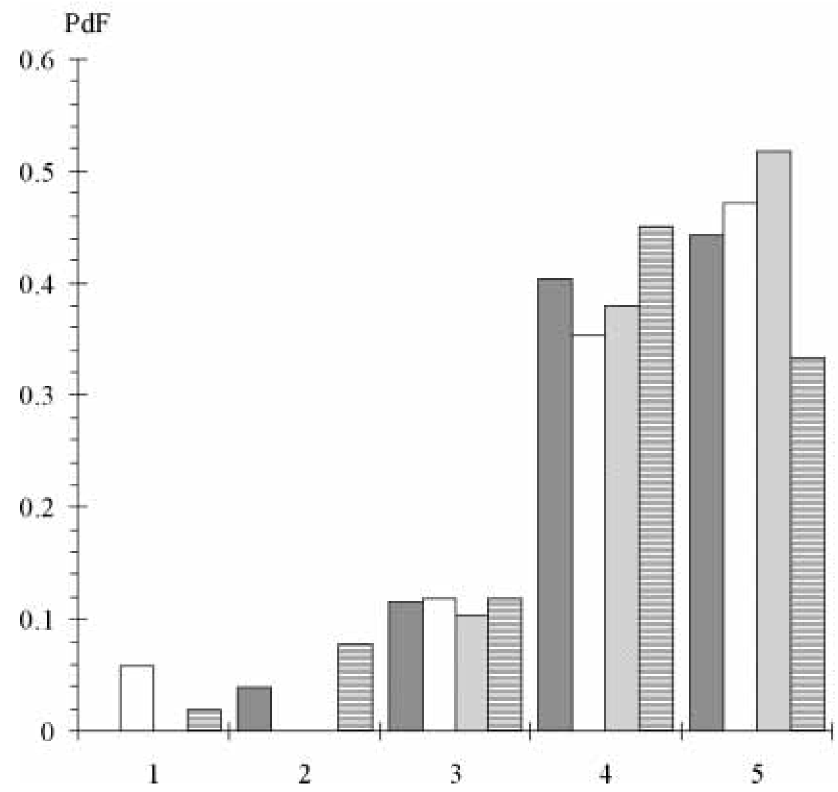
Summary and conclusions

Field studies complement traditional lectures and laboratory work. Student fieldwork was introduced systematically in a series of hydraulic engineering subjects within undergraduate civil and environmental engineering curricula. Anonymous student feedback demonstrated a strong student interest for the fieldwork. This was associated with greater motivation for the course, leading in turn to lower failure rates. Feedback from former students indicated that fieldwork experience was an important component of their studies and helped their professional development. Employers testified that fieldwork are an essential component of a hydraulic engineering course and that it should be a requirement in all civil/environmental engineering curricula.

This pedagogical experience demonstrated the very-significant role of fieldwork in the teaching of hydraulic engineering. Lecturers and professionals should not be complacent with university hierarchy and administration clerks intent on cutting costs by eliminating field studies. Although the preparation of fieldwork with large class sizes is a major effort, the outcome is very rewarding for the students and the lecturer. Yes, fieldwork should be definitely compulsory in each and every hydraulic engineering course !

Anonymous student feedback from undergraduate field studies conducted in 2002-03

“All things considered, do you think that fieldwork and site visits are an important component of the (civil/environmental engineering) curriculum ?”



- Open channel flow (58/84 response rate)
- Civil design (51/73 response rate)
- Hydraulic design (18/24 response rate)
- Mixing in rivers/estuaries (29/39 response rate)

1 = Disagree
2 = Unsure
3 = Agree moderately
4 = agree strongly
5 = Agree very strongly

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People and places

Dr Andreas Müller retires from ETS, Zurich

Andreas Müller, Vice President of IAHR 1998-2001, has recently retired from ETS, Zurich. Former Secretary-General, HenkJan Overbeek, and former President Helmut Kobus, represented IAHR at Andreas' retirement ceremony.

Dr. E.M. Valentine moves to Darwin, Australia

JHR Associate Editor, Eric Valentine has been appointed to the post of Power and Water Foundation Chair in Civil Engineering at the Charles Darwin University, Darwin, Australia starting April 7th.

The chair is sponsored by the Power and Water Corporation of the Northern Territory. They particulary wish to stimlulate research in the "top end" on Darwin Harbour hydrodynamics and on tropical river systems. They also wish to encourage the development of a local capacity in civil engineering.

Prof Valentine will not be losing contact with his former base at Newcastle upon Tyne, as he will remain a Visiting Professor.
eric.valentine@cdu.edu.au

Article on Paul Duboys in the next issue of JHR

He was the founder of scientific fluvial hydraulics, who proposed in 1879 the first formula for sediment transport in rivers. If you would like to know more on this distinguished hydraulician, look out for the historical paper in the Journal of Hydraulic Research Vol. 43 (3) (upcoming publication).

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Convocation of the 2005 IAHR General Members Assembly

All IAHR members are cordially invited to attend the IAHR General Members Assembly to be held on Friday 16th September, 2005, Seoul, Korea

Venue: COEX Convention Centre, Seoul, Korea

Time: 16:30

AGENDA
Opening
Announcements
Minutes of the 2003 General Members Assembly, Thessaloniki
2004 Financial Report
2004 Annual Report of Association Activities
IAHR 2005-6 Council Election Results
Closure

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