THE IMPORTANCE OF FIELD WORKS IN THE UNDERGRADUATE TEACHING OF HYDRAULIC ENGINEERING

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Abstract : The writer re-visits the pedagogical impact of field works in undergraduate hydraulic engineering subjects. Numerous field studies were organised as part of hydraulics subjects in a broad-based civil engineering curriculum during the last 10 years. Anonymous student feedback indicated a strong motivation for hydraulic courses that include a field work componenet, associated with lower failure rates. Employers' response showed a very strong industry support for field works which must be a curriculum requirement. This experience shows also that the selection of field trips is critical to maximise students' learning.

Keywords : undergraduate teaching, field studies, students' response, employers' feedback

INTRODUCTION

The Merriam-Webster's Collegiate Dictionary defines engineering as "the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people". Engineering graduates must be familiar with real-world problems, practical applications and relevant solutions. During the last three decades, universities in developed countries have rationalised their engineering curricula. This has been associated with the development of computer-based courses and project-based subjects, often at the expenses of practical studies and field works. The situation is well illustrated by trends in engineering education journals. Between Jan. 2000 and Dec. 2001, the *International Journal of Engineering Education* included 57 papers on computer-based engineering courses, including 12 on "virtual teaching", plus 11 papers on quality assurance and over 32 papers on project-based courses, out of a total of 139 published articles. Not a single article described field work to support basic teaching. This alarming trend is also true in the teaching of hydraulic engineering. In a recent issue of the *Journal Hydraulics Engineering* (Vol. 126, No. 12) on "Teaching Hydraulic Design", only one paper discussed the role of field studies to support the teaching of hydraulic engineering (CHANSON 2001).

In the present paper, the writer re-visits the significant role of field studies as part of the undergraduate teaching of hydraulic engineering in a civil engineering curriculum. The paper is based upon the writer's experience at the University of Queensland (Australia). It is documented with anonymous surveys of undergraduate students, questionnaires to young graduates and employers. The results demonstrate strong student motivation for hydraulic courses associated with field works, and very-strong industry support and requirement, for such hands-on experience.

FIELD STUDIES IN UNDERGRADUATE TEACHING OF HYDRAULIC ENGINEERING

At the University of Queensland, hydraulics and water resource engineering are lectured in the civil and environmental engineering curricula. Following a common first year to all engineering degrees, the students are taught hydraulic engineering in a series of compulsory and elective subjects. Typical class sizes are about 80 to 150 for compulsory subjects and 25 to 80 students in elective subjects. Following a change in curriculum late 2001, the compulsory subjects include CIVL2140 Hydrology in 2nd year, CIVL3130 Fluid mechanics

and CIVL3140 Open channel flows in 3rd year and a component of CIVL4510 Civil design in 4th year (Table 1). Elective subjects are typically taught in 4th Year although some might be undertaken in late 3rd Year.

Table 1 - Undergraduate teaching of hydraulic engineering in the civil engineering curriculum at the University of Queensland

	2nd Year	3rd Year	4th Year
Compulsory subjects	CIVL2140 Hydrology	CIVL3130 Fluid Mechanics CIVL3140 Open channel flows (+) (*)	CIVL4510 Civil design (30%) (+) (*)
Elective subjects			CIVL4140 Mixing in rivers (*); CIVL4110 Coastal hydraulics (+); CIVL4120 Hydraulic design & structures (+) (*)

Notes : (+) subject associated with field trips; (*) subject lectured by the writer in 2001 and 2002.

Fig. 1 - Photographs of undergaduate student field trips
(1.1) CIVL3140 Open channel flow class (84 students) in Gold Creek dam stepped spillway

Pedagogy of the hydraulic engineering course

The course material is structured to guide the students from the basic principles of fluid mechanics to their application to engineering design. In the compulsory Open channel flow subject (CIVL3140), simple hydraulic modelling is introduced as a series of tools used by professionals to compare the performances of various design options. Two types of models are introduced : i.e., physical models associated with laboratory experiment classes, and numerical modelling of steady, gradually-varied flows. In more advanced elective subjects,

the students are introduced to movable boundary hydraulics (CIVL4110 & 4120), numerical modelling of unsteady open channel flows (CIVL4120) and design of dam spillways (CIVL4120). Analytical models of mixing and dispersion in rivers and estuaries are introduced in other electives (CIVL4110 & 4140).

In the context of undergraduate subjects, design applications are restricted to simple flow situations and boundary conditions for which the basic equations can be numerically integrated. A sound teaching pedagogy should include field works associated with tutorials and projects. Field studies (Fig. 1) are essential to illustrate real professional situations, and the complex interactions between all engineering and non-engineering constraints (CHANSON and JAMES 1998, CHANSON 1999,2000). For example, a culvert design requires a hydrological study of a stream to estimate the design flow rate and to predict the risks of emergency conditions. The dimensions of the culvert are based on hydraulic, geotechnical and structural considerations, and the impact of the culvert on the environment must be taken into account : e.g., flooding of the upstream plain, tailwater conditions (Fig. 1.3).

(1.2) CIVL4120 Hydraulic design class (24 students) in front of the fully-silted Korrumbyn Creek dam in a dense sub-tropical rainforest

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. Figure 1 illustrates some examples. Figure 1.1 shows CIVL3140 Open channel flow students inspecting the Gold Creek dam spillway. Key features include a 55-m wide, 60-m long broad crest, a stepped chute and the absence of downstream stilling basin. Completed in 1890, the long-lasting operation of the spillway demonstrates its successful design

(CHANSON and WHITMORE 1998). Figure 1.2 shows CIVL4120 Hydraulic design students in front of the fully-silted Korrumbyn Creek dam. The dam and reservoir were accessed after a half-hour bushwalk guided by the rangers in the dense sub-tropical rainforest of Mt Warning National Park (NSW). Figure 1.3 presents CIVL4510 Civil design students surveying a Minimum Energy Loss culvert. During the exercise, students working in groups surveyed eight culverts and flood plains. Each group conducted hydraulic computations for design and less-than-design flow rates, and prepared a newer design for a larger flood. The results were presented in a series of reports and oral presentations, assessed by student peers and lecturers.

(1.3) CIVL4510 Civil design students (73 students) surveyinf a M.E.L. culvert outlet and dowsntream flood plain (Courtesy of L. CHEUNG)

SURVEY RESULTS

Anonymous student feedback were collected after three field works in 2002 in two compulsory subjects (CIVL3140 and CIVL4510) and one elective subject (CIVL4120) (Table 1). The assessment component of the field works and the type of assessment are summarised in Table 2. Figure 2 presents some results of anonymous student feedbacks. Table 3 lists relevant websites.

Overall the anonymous results demonstrate that students considered field works as an essential component of the hydraulic engineering courses and an important aspect of the civil engineering curriculum. They perceive a clear difference between a construction site visit and the investigation of a hydraulic structure in operation (or disused). Field works encouraged strong group bonding. They are well-suited for group works, allowing students to gain better in-depth understanding of professional teamwork and designs. Although the students believed that field studies do not replace traditional lectures, most felt that the field experience helped them to think more critically in hydraulic engineering. In particular, Figure 2.2 highlights that 85 to 90% of the students believe that field works play "a vital role to comprehend real-word engineering". Anonymous results indicated further that field studies were not self-learning.

Students needed expert guidance and knowledge to comprehend all aspects of a prototype design. In some instances, students conducted field visits on their own. The outcome was disappointing, their reports indicating that they learned little and missed vital issues. Most students regarded field study supervision as necessary to gain first hand knowledge on successful designs.

Handwritten and verbal student feedback indicated a strong student motivation for hydraulic courses associated with field works. Field trips helped the students to visualise professional situations. They motivated them significantly more than conventional lectures and audio-visual aids (e.g. slides, video). This interest for the course translated always in higher marks in homeworks and examination papers, and, more importantly, a much smaller failure rate in these subjects. Prior to the introduction of field works, the failure rate in hydraulics subjects was about 15 to 30% over a ten year period. Since the introduction of field works, the failure rate, in the same subjects, has been reduced down to 5 to 20%. The impact of field works on students' performances was most felt among the "tail" of the class (i.e. low GPA students). Failure rate among students with low GPA was reduced by nearly 70%. In several instances, individuals were noted to "switch on" during field works and some students commented: "I gained interest for the course thanks to the field trips".

In addition, the writer interviewed a number of former students : i.e., graduates with less than 5 years of experience. For a sample of over 30 young graduates, 95% had a vivid memory of the field trips in hydraulics; 90% believed strongly or very-strongly that field works were an important part of the curriculum and 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 over 25 senior engineers, all (100%) stated that field experience, including field works under academic supervision, was a basic requirement for a civil engineering degree.

Table 2 - Field works in undergraduate hydraulics subjects, conducted in 2002, at the University of Queensland

Subject	Nb of students	Field work sites	Assessment component of subject	Type of assessment	Remarks
CIVL3140 Open channel flow	84	Minimum Energy Loss culverts & Gold Creek dam spillway	5%	Individual report.	3rd Year compulsory subject.
CIVL4510 Civil design	73	Minimum Energy Loss culverts & Flood plains in Norman Creek catchment	20%	Group report and group oral presentation (8-9 students per group).	4th Year compulsory subject.
CIVL4120 Hydraulic design	24	Fully-silted Korrumbyn Creek dam reservoir, Hinze dam spillway & Molendinar Water Purification Plant	10%	Group report (4-5 students per group).	4th Year elective subject.

Fig. 2 - Anonymous student feedback from undergraduate field studies conducted in 2002 in the subjects CIVL3140 Open channel flow (84 students), CIVL4510 Civil design (73 students) and CIVL4120 (24 students) - Horizontal scale : 1 = Disagree, 5 = Agree Strongly
(2.1) "The field work was an important component of the subject"

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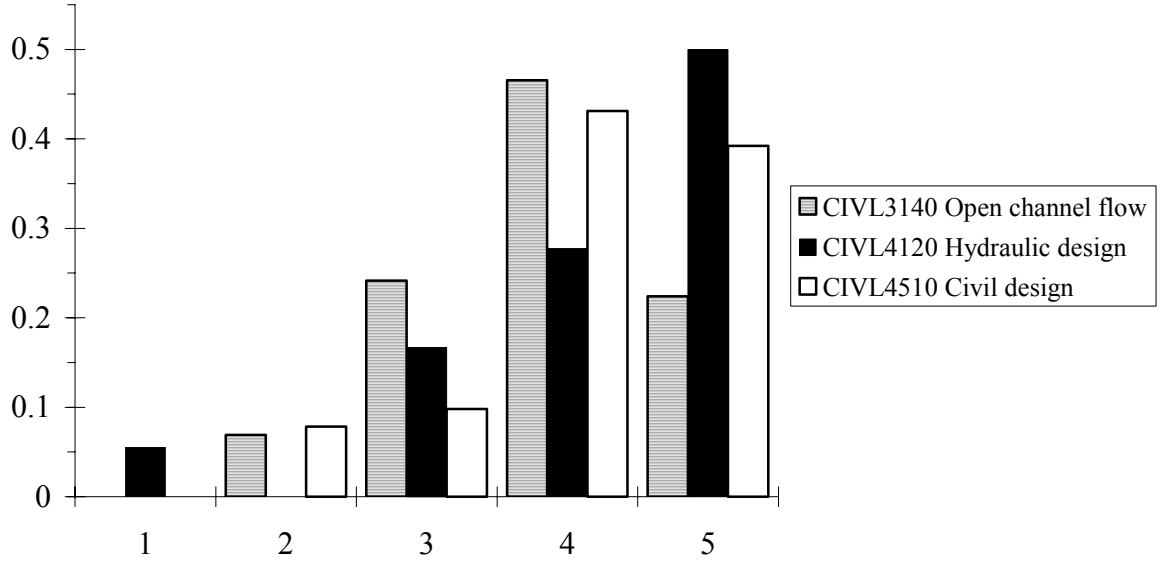

DISCUSSION

Anonymous feedback and discussions with students highlighted the importance of appropriate on-site guidance and expertise, associated with enthusiastic lecturers. Students can become quite exited at relevant hydraulic sites directly relevant to the course. For example, a culvert is often a "dull" structure in the classroom, but it may become a fascinating hydraulic structure in the context of a hydraulics field trip.

With over 29,00 students, the University of Queensland is by far the largest and most prestigious university in the State of Queensland, and it is regarded as one of the four top universities in Australia, with the Universities of Melbourne and of New South Wales (Sydney). Although the University of Queensland might not be strictly characterised as an average university, its undergraduate civil engineering curriculum is representative of a strong focus on water resources in Australasia.

CONCLUSION

Student field works were introduced as part of a series of hydraulics subjects in an undergraduate civil engineering curriculum. Anonymous student feedback demonstrated a strong interest of the students for the field works. This was associated with greater student motivation for the course, leading in turn to lower failure rates. Feedback from former students indicated that field work experience was an important component of their studies and helped them in their professional development. Employers testified that field works is an essential component of the hydraulic engineering course and that it should be a requirement of all hydraulic engineering curricula.

The present study demonstrates the very-significant role of field works in the teaching of hydraulic engineering. Lecturers and professionals should not be complaisant with university hierarchy and administration clerks to cut costs by eliminating field studies. Although the preparation and organisation of field works with large class sizes are a major effort, the

outcome are very rewarding for the students and the lecturer. From his own experience, the writer has had great pleasure and satisfaction to bring over 1,000 undergraduate students in hydraulics field studies during the last decade.

ACKNOWLEDGMENTS

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REFERENCES

CHANSON, H. (1999). "The Hydraulics of Open Channel Flows : An Introduction." *Butterworth-Heinemann*, Oxford, UK, 512 pages.

CHANSON, H. (2000). "Introducing Originality and Innovation in Engineering Teaching: the Hydraulic Design of Culverts." *European Jl of Engineering Educ.*, Vol. 25, No. 4, pp. 377-391.

CHANSON, H. (2001). "Teaching Hydraulic Design in an Australian Undergraduate Civil Engineering Curriculum." *Jl of Hyd. Engrg.*, ASCE, Vol. 127, No. 12, pp. 1002-1008.

CHANSON, H., and JAMES, P. (1998). "Teaching Case Studies in Reservoir Siltation and Catchment Erosion." *Intl Jl of Engineering Education*, Vol. 14, No. 4, pp. 265-275.

CHANSON, H., and WHITMORE, R.L. (1998). "Gold Creek Dam and its Unusual Waste Waterway (1890-1997) : Design, Operation, Maintenance." *Can. Jl of Civil Eng.*, Vol. 25, No. 4, Aug., pp. 755-768 & Front Cover.

Table 3- Relevant websites and Internet resources

CIVL3140 Open channel flows website	{http://www.uq.edu.au/~e2hchans/civ3140html}
CIV4120 Hydraulic design & structures website	{http://www.uq.edu.au/~e2hchans/civ4120html}
CIVL4510 Civil design website	{http://www.uq.edu.au/~e2hchans/civ4510html}
Extreme Reservoir Siltation in Australia	{http://www.uq.edu.au/~e2hchans/res_silt.html}
Hydraulics of Minimum Energy Loss Culverts	{http://www.uq.edu.au/~e2hchans/mel_culv.html}
Gold Creek Dam Historical Stepped Spillway	{http://www.uq.edu.au/~e2hchans/gold_crk.html}

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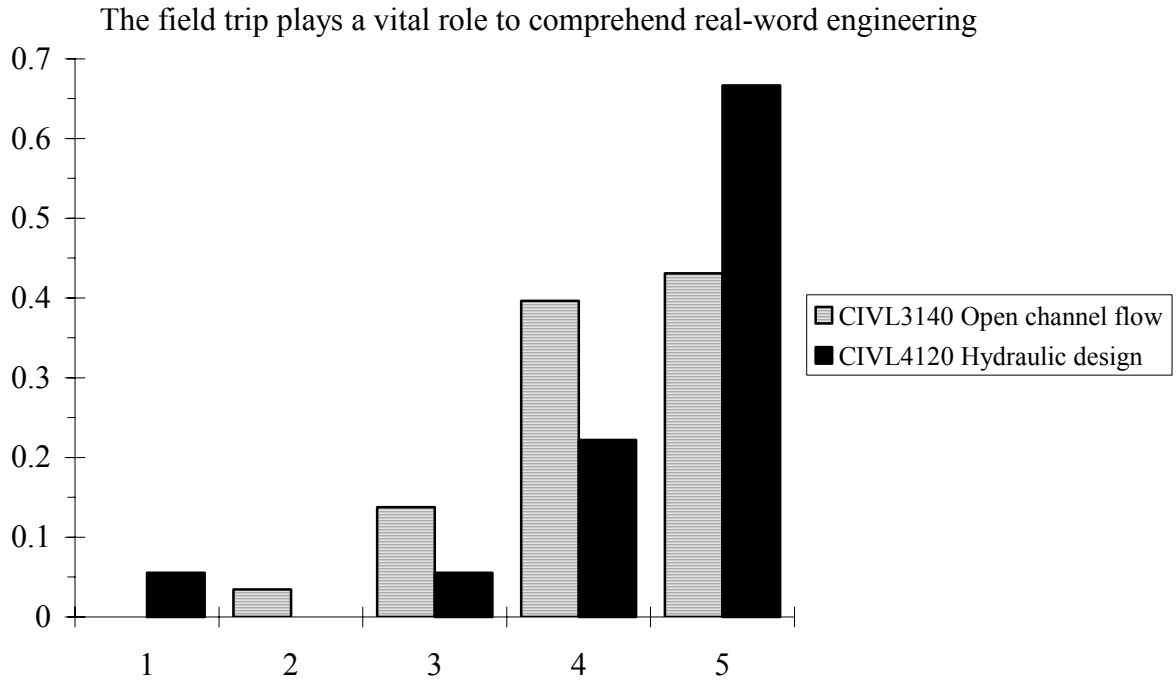

(2.3) "All things considered, do you think that field works and site visits are an important component of the (civil engineering) curriculum ?"