Creating better learning environments by cross-disciplinary collaboration: a civil engineering and surveying linkage

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Abstract: *Many of the teaching elements in Civil and Environmental Engineering and Spatial Science/Surveying are strongly related to multidisciplinary real-world situations. Professionals in each discipline commonly work collaboratively, knowing each other's professional and technical limitations and requirements. Replication of such real-world situations allows students to gain an insight and acquire knowledge of professional practice for both civil engineering and spatial science disciplines. However, replication of an authentic design project is not always possible in a single unit basis where empirical project situations are often created with controlled sets of constraints, inputs and outputs. A cross-disciplinary design-based project that is designed to promote active student learning, engagement and professional integration would be the preferred option. The central aim of this collaborative project was to create positive and inclusive environments to promote engaging learning opportunities that cater for a range of learning styles with a two-way linkage involving third-year civil engineering and spatial science (surveying) students. This paper describes the cross-disciplinary project developed and delivered in 2010 and 2011. A survey was conducted at completion of the project to assess the degree of improvement in student engagement and their learning experiences. Improvements were assessed in a range of dimensions including student motivation, learning by cross-disciplinary collaboration and learning by authentic design project experiences. In this specific cross-disciplinary linkage project, the study findings showed that teaching approaches utilised have been effective in promoting active student learning and increasing engagement.*

Introduction

Engineering and spatial science graduates of today are expected to develop the ability to transfer basic knowledge to real-life engineering design and construction situations; ability to work in multi-disciplinary teams; ability to adapt to change and solve problems in unfamiliar circumstances; ability to think critically and creatively: and a commitment to continuous life-long learning and self improvement (Ribeiro & Mizukami, 2005; Thoben & Schwesig, 2002). As a result, a new era is emerging in engineering and spatial science education driven by the recognition that university graduates need to be better prepared for today's rapidly changing professional work environment. It is essential to create authentic design experiences for engineering and spatial science students that simulate the demands of real professional practice. This has led to educators adopting group based and project based strategies that give students the opportunity to develop these skills by embedding them across the university curriculum. These strategies are delivered through activities that also help develop other graduate attributes such as ability to identify, formulate, and solve engineering problems, inclusively manage diversity of team members and the ability to communicate effectively.

The use of collaborative teams to promote student learning in higher education has become more prevalent as a result of increased class sizes along with flexibility to cater for different learning styles. It encourages active learning and assessment can be easily varied. Many team activities in engineering and spatial science focus on open ended design based projects in formal learning groups where students work together in small groups to achieve common goals. Finelli et al 2001 found that it was essential to integrate five elements; positive interdependence, interaction, individual accountability, interpersonal skills and group processing into any activity. An important aspect of active collaborative learning is that the team building process needs to be informed by good practice from the teaching team. There are some known problems in teaching fundamental engineering, spatial science and design related concepts. They can be complex and appear abstract, making it challenging for students to relate theory to real-world situations. To support this, Hirsch and McKenna (2008) found that supplying students with authentic design projects increase their motivation to perform. Enhanced teaching materials and relevant teaching techniques are often used to communicate complex concepts in engineering and spatial science. However, these techniques are still not comprehensive enough to replicate authentic design scenarios.

By providing learning environments rich in varied learning methods, educators can provide students with a diverse means of receiving and applying knowledge and information resulting in a more engaging and interactive educational setting (Scott et al., 2003). Lin &Tsai, 2009 found that learning environments which are student centred, peer interactive and teacher facilitated help students develop more fruitful conceptions of learning engineering. Studies showing that students in undergraduate engineering and spatial science exhibit a stronger preference for the active sensing, visual and sequential learning styles indicate that integrated active teaching and learning experiences can have an enormous impact on student motivation and engagement (Felder and Brent, 2004; Gibbings and Brodie, 2006). There is a myriad of sources confirming the proposition that we learn best by doing, whilst recognizing that learning is a combination of many different interactions (Dawes et al, 2005).

There is a growing consensus around 'good learning', perhaps best summarised by thinking of learning as a guided process of knowledge-construction (Biggs, 1999). We are likely to have greater success in improving student engagement and better learning outcomes if we design in accordance with a model that emphasises these learning styles. Understanding how students learn is an important aspect of designing useful and functional learning resources. In this project resources were developed online and student groups were presented with unique development options. This includes web based, visualisation modelling and instructional resources accessible to students across different years of their undergraduate course. The project objectives were to build capacity to deliver improved student learning experiences, develop enhanced student engagement and potential transferability across many other disciplines.

Methodology

The project framework was driven by the connections between individual project outcomes across three units. The catchment analysis project for a third-year water engineering unit was based on the key project deliverables of a second-year unit focusing on sustainable development including layouts for subdivisions and infrastructure. The land survey management and visualisation project in the spatial science unit develops detailed catchment profiles and terrain mapping essential to undertake the catchment analysis project. The key deliverables for this integrated catchment analysis project was a detailed design of stormwater drainage and culverts including flood envelopes. This supported a proposed land development proposal for the subject site inclusive of sustainability objectives. Student groups were provided with resources required to achieve the key deliverables.

The student-centric tasks were primarily formulated based on the actual site conditions at QUTs Samford Ecological Research Facility (SERF) where students have controlled access. The site has geographical, land-use and ecological characteristics and datasets essential to achieve the key deliverables inclusive of the cross-disciplinary collaborative approach. These datasets included digital and paper format topographical, land-use and recent aerial photographic imagery along with land-survey control network and related site-specific spatial infrastructures (Webb, 2010).

To aid the active learning objective prior to the site-visit, a digital terrain visualisation model was constructed and formed a key visual information layer inside the survey measurement simulator. This allowed the student group to preliminarily assess their concept designs with respect to the likely terrain aspects of their proposed engineering structure solution. This task, exposed their technical hydrology considerations and drainage calculations to some rigour to assess if their proposed engineering solution was fit-for-purpose. The experiential learning component involved a fieldwork site-survey, about a half-hour bus journey from the university campus. A major challenge encountered in both delivery years was the logistics of transport to and from the site, field survey equipment and tutors necessary for the activity involving some 200 students, along with some hurdles with safety aspects essential to undertaking this scale of detailed land-survey activity in a semi-rural environment. After completion of the sequential field site-survey activity, the surveying students in the group provided a lead role to post-processing measurement observations to deliver detailed catchment profiles and terrain mapping essential to the catchment analysis activity with student groups fine-tuning aspects of the hydrological engineering solution.

Creating a positive environment for engaging learning opportunities was realised through a number of knowledge constructive tasks along the learning journey. Initially the unit coordinators mapped out their individual unit tasks with knowledge transfer sessions and aligned key dates incorporating this cross-disciplinary 25% unit assessment project. Both student classes in core units Water Engineering and Cadastral & Land Management units engaged the same academic staff in the delivery of the sub-element teaching to realise successful achievement of the key deliverables. Assessment of tasks was undertaken with an agreed criterion reference assessment approach.

Some reflective feedback from tutors and academic staff relating to the 2010 assessment indicated some imbalance of student expectations within the collaborative student teams. In the 2011 delivery, an incremental improvement was the introduction of a student agreement of subtask activities, in matrix form, to clarify individual student responsibilities and workloads. Student feedback indicated this matrix tool provided clarity across the diversity of student group members.

Results and Discussion

In order to determine whether a cross-disciplinary authentic design project contributed to better student engagement and promoted active student learning, the authors devised a paper based survey around the two existing core units. It is commonly known that the students' feedback and reflective responses is a key to determine achievements of teaching and learning interventions. The purpose of the survey was to answer the following questions:

- How effective are authentic design projects in undergraduate learning?
- How effective are cross disciplinary projects in promoting active student learning and increasing student engagement?

The survey focused on four components primarily to gather data on student characteristics, gather student opinion on the material provided, project design, gather data on students' learning experience and students' voluntary comments on the project strengths and weaknesses. A four component survey was designed inclusive of the influence of difference in study discipline and gender on responses (Mitchell et al, 1996). The criteria used for student grouping, academic year and details of the student cohorts surveyed are shown in Table 1.

Table 1 – Details of the responding student cohorts

Year	Discipline		Gender		Academic year			Criteria used for grouping
	Civil Eng.	Surveying	Male	Female	2nd	3rd	4th	
2010	75	8	69	14	2	68	13	Student selected a partner, lecturer joined pairs into teams
2011	97	16	100	13	0	90	19	Students were allowed to form groups according to their preference

Responses to assess students' overall project learning experiences, including peer-learning, field and project based learning are summarised in Figure 1(a-e). Responses focusing on assessing students' opinion on support provided are summarised in Figure 1- (f). Figure 1 shows the difference in feedback received for 2010 and 2011 is nominal (no significant difference between years Chi-square test) and could be attributed to differences in discipline mix, gender mix and criteria used for grouping as highlighted in Table 1. Due to this reason, the difference in feedback for 2010 and 2011 are not discussed in detail. We have used both years' data to assess the overall learning experience and satisfaction.

Figure 1 shows 60 to 80% of the students responded positively (strongly agree or agree) to all five questions that inquire about their learning experiences. This suggests that the project was successful in many aspects. In particular, almost 80% of the students agreed that the project provided better understanding of the importance of water engineering to real-world scenarios (Figure 1-(c)), while less than 10% disagreed. This is a positive indication of the appropriate formulation of the project in terms of technical content and tasks and students' perception aligning them with authentic design scenarios.

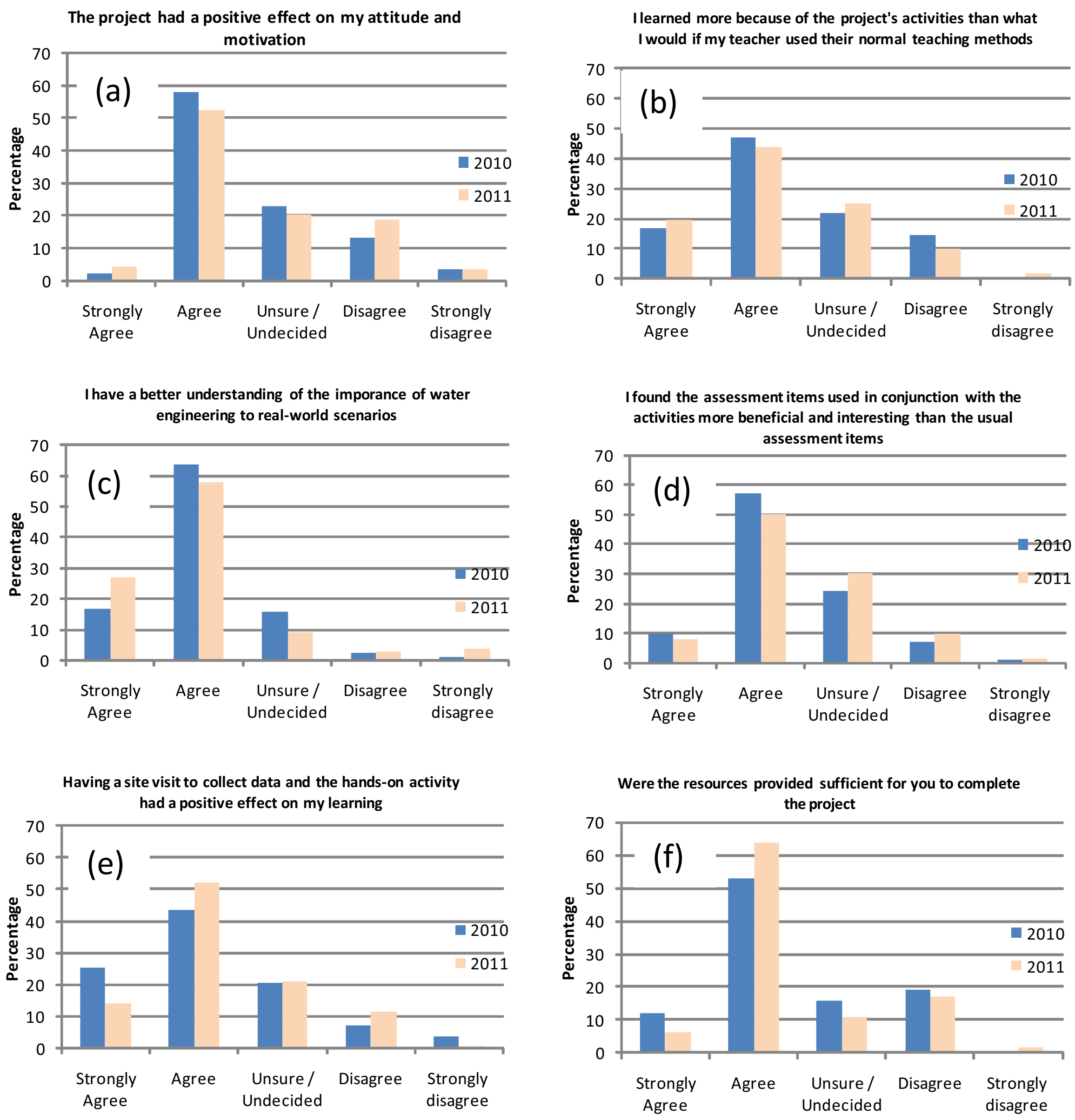

Figure 1 – Summary of feedback on students' learning experiences

The survey responses shown in Figure 1-(a), (b), (d) and (e) focus on the learning experiences students perceived during the project. Figure 1-(a) illustrates more that 60% of the student cohorts agreed that the project had a positive effect on their attitude and motivation. However, 20% of the students were unsure and 10-20% of the students disagree that the project is a positive experience. Similarly, more than 20% were unsure and around 15% of the students do not think the project provided a better learning experience than the typical class room teaching (Figure 1-(b)). More than

25% were unsure and around 10% do not think that the project provided better learning experiences compared to other typical assessment items (Figure 1-(d)). This may indicate a mismatch between the students' preferred learning style and environment and the actual learning environment.

This leads us to conclude that over 60% of the students rate the teaching and learning experience they had during the project as positive in comparison to typical class room learning and other typical assessment items. However, learning opportunities created with around 30% of the student cohort is a concern and needs some further investigation. It appears the minor adjustments to the project in terms of support and resource provided and grouping criteria had no effect on changing the student learning experiences over the two delivery years (Chi-square test confirmed this). This indicates that the material and support provided, or having a social loafer in the group, is not the reason for the project to be a less than rewarding experience. It could be the fundamental learning modes that this design project offers, such as peer-learning through cross-disciplinary collaboration and/or having hands-on experiences, are the main reasons for some students to be unsure in their response.

Responses informing Figure 1-(e) indicate that around 20% were undecided and around 10% disagree to the notion that the field site-visit and hands-on exercise provided positive learning experiences. These percentages are equivalent to the feedback provided for the remaining questions on learning experiences. However, an analysis of the support and resources provided is vital to provide conclusive remarks. As indicted in Figure 1(f), around 15% were unsure and around 20% disagreed that they were provided with adequate resources.

A representative selection of student comments below affirms the overall positive learning experience for this authentic design project.

- 4th year student male engineer: "Using a real world example greatly enhanced the interest and relevance of the project".
- 3rd year student female engineer: "The project was conducted at a site we had previous experience. This helped me understand the project more clearly and be more motivated to complete the task".
- 3rd year student male surveyor: "Collaborating with students outside my discipline was rewarding. The use of a real world example using a real site made the project more realistic."
- 3rd year student male surveyor: "Interacting with the engineering students was enlightening".

The student feedback and observations indicate that the close replication of authentic design scenarios in undergraduate learning projects can also create an adverse influence on learning experiences for a number of students. In this project teaching staff promoted peer-learning and self-learning in a design project environment and only provided standard information where significant processing required converting into requisite information to derive outcomes. Furthermore, this project was formulated to share knowledge and expertise at a cross-disciplinary level.

Conclusion

This collaborative cross-disciplinary project aimed to replicate authentic design scenarios in teaching engineering and spatial science (surveying) concepts. In this project, virtual and physical learning environments were created such that students could actively participate in learning activities, cross collaborating with students in different academic years and disciplines. The project highlighted the appreciation of professionals working collaboratively to achieve common goals whilst inclusively respecting each other's professional and technical limitations and requirements.

Using the analysis of the responses to the survey over two delivery years this paper provides an insight to assessing the effectiveness of authentic design projects in undergraduate learning and effectiveness of cross-disciplinary projects in promoting active student learning and increasing engagement. The outcomes affirmed that these projects are effective in undergraduate learning and have been successful in promoting active student learning and increasing engagement. Based on students' responses, the project has provided an improved technical understanding of discipline areas and positive learning experiences. However, the project structure and learning environment did not closely align with learning approaches of 30% of the students. Analysis indicated that this may not be due to project formulation but due to some students being oriented toward retention of facts and analytical skills whereas the project required design thinking. Limited close supervision, lack of support and requirement to have cross-disciplinary collaboration are other reasons that may have lead to these responses.

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Acknowledgements

This project enabled students to develop skills across discipline boundaries with acknowledgment of the seed-funding by a QUT Small Teaching & Learning Grant in 2009. The authors would like to acknowledge valuable inputs from the technical support staff for their assistance and cooperation over the past two years in the production of instructional resources including Mr. Graham Blair for software enhancement of the survey measurement simulator software and Mr. Ian Pagan for production of the high-resolution ortho-rectified aerial photographic imagery.

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