AAEE 2012 CONFERENCE
Melbourne, Australia
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Research Based Learning: A Coastal Engineering case study

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BACKGROUND
This paper presents findings from the implementation of a research based learning (RBL) approach into a coastal engineering elective course. The approach is essentially a project based learning approach with an integrated element of research. This study had two primary objectives: (1) to develop student's generic data analysis, report writing and group work skills whilst, (2) integrating ongoing research activities into undergraduate teaching.

PURPOSE
The purpose of this paper is to answer the question: "Is a research based learning approach to a coastal engineering elective course effective in terms of student engagement and learning outcomes?"

DESIGN/METHOD
4103ENG Advanced Coastal Engineering is an elective course available to students undertaking a Bachelor of Engineering (Civil) at Griffith University which has historically been taught using a traditional "chalk and talk" approach. In the 2011 offering, 29 students followed a staged, research based learning approach with a research element encouraged through assessment criteria. The first assessment module assisted students to develop and evaluate the required data analysis tools using Matlab that would be later applied to two small research projects assessed via report submission. The two subsequent research projects initially involved time in the laboratory conducting physical model experiments of (1) wave energy dissipation due to a breakwater and (2) wave transformation through the surf zone. In each case, students were given some background literature on relevant theory to evaluate using their experimental data and for this they could achieve a maximum grade of a Distinction. The independent research aspect for each project was then encouraged by informing students that to achieve a High Distinction grade would require their own critical enquiry of additional theories from the literature.

RESULTS
The new approach was well received by students who generally strongly agreed that the course was well organised, had clear and fair assessment, gave good feedback, was engaging and had effective teaching. In addition, gave a an overall course rating score of 6.3/7 for the RBL course mode as compared to the previous two offerings of the course that respectively received 5.76 and 5.25 out of 7. Students also had the following to say about the course:

- "*… a great course to get students minds working, improve analytical skills and Matlab skills, very helpful course for data analysis, reporting and researching skills (helpful for future)*"
- "*The assignment based structure was excellent as it allowed for research into other areas of coastal engineering where students could engage in their style of learning at their own pace. The labs were interesting as they applied to real world situations and encouraged research.*"

CONCLUSIONS
The introduction of a research based learning approach to an undergraduate coastal engineering elective course was well received by students who indicated it engaged them and improved their understanding of the field and improved their generic data analysis and report writing skills in the process.

KEYWORDS
Research based learning, coastal engineering

Introduction

This paper presents findings of a case study of the implementation of a research based learning (RBL) approach to a coastal engineering elective course. RBL is basically a guided project based learning approach with an element of independent research by students encouraged through appropriate byassessment criteria.

Project based learning approaches are well proven to motivate students with exposure real-life design problems whilst helping develop generic skills (e.g. (Kosse & Hargreaves, 2004; Oberst & Schnegas, 2004)) and to create and maintain a proactive teaching and learning environment (de Silva, 2004). In addition to this, research driven universities strongly encourage the integration of current research within undergraduate teaching.

Interestingly, after this study was conducted, a paper presented at the 2012 International Conference on Coastal Engineering by eminent coastal engineering researcher and educator J. W. Kamphuis suggests that, due to increasing demand in the present era of climate change "*Our existing systems will NOT be able to meet future needs for coastal engineers. And is not able to meet present needs!!*" (Kamphuis, 2012). He goes on to suggest a teaching model which focusses more on design and to "*make access to simulation and physical laboratory facilities for teaching purposes a priority in coastal engineering education*." Whilst this course does not really have a complete design element to it as such, it does entail an assessment of a given design and for the most part is based on physical modelling and data analysis and predictive model evaluation.

Methodology

When introducing a new teaching delivery mode such as project/RBL to students mostly familiar with the traditional chalk and talk approach, it is important that sufficient guidance is provided and that objectives of the new approach are made clear to students (Lemckert, 1999). This was achieved in the present context with 2 hour weekly interactive workshops which were used to (a) clarify learning objectives and provide introductory background knowledge and (b) to provide ongoing guidance throughout the project in a fashion not dissimilar to a research student-supervisor relationship.

The course content and structure was developed so that it focussed on one of the fundamental skill sets required of a coastal engineer, namely the ability to collect and analyse water level data. These skills are needed to derive representative wave characteristics in order to design and/or assess a coastal engineering design problem.

The approach adopted was essentially two-phased. Firstly, an introductory module was undertaken to assist and assess individual students on the development of the required data analysis skills and tools using Matlab. Secondly, two independent research projects were conducted in small groups of 2 or 3 students. Each project consisted of a session in the laboratory to collect data from a physical model with follow up weekly supervised computing lab workshops to process and analyse the data using the tools developed in module 1. The first project was based on the assessment of wave energy dissipation induced by a given breakwater design and of the performance of predictive design formulae. The second project was based on the assessment of wave energy dissipation due to breaking through a surf zone and of the predictive capabilities of a simple parametric type wave transformation model.

The author notes that this type of approach would not readily be transferable to all undergraduate engineering courses where more content needs to be covered and assessed. Since this is an advanced elective course it did lend itself to a change to the RBL approach. In the course, the quantity of topics was reduced but the expectation in terms of going in to more depth was enforced through assessment criteria. It may be perceived that the adopted one on one, supervisor-student learning and teaching relationship could potentially be quite costly in terms of teaching hours per student. However it was found in this case that there were often recurring questions from students in which case the discussion and answer was undertaken with the entire class. In addition the use of group work led to more student-student interaction and even group-group interaction when analysing and interpreting the data. It is unknown how the time costs would change when trying to scale up to a larger class size (the present class enrolment was 29) but, in theory, should still be manageable with the help of well qualified and trained teaching assistants.

Module 1: Data analysis skill development

The learning objective for this module were for students to develop a Matlab program which automated the data analysis required to extract wave characteristics from an observed time series of water level fluctuations. The two analysis methods used were: (1) a zero-crossing analysis to divide the water level record up into individual waves from which statistical measures of wave properties could be derived and (2) spectral analysis which converts the time series into a distribution of wave energy as a function of frequency thus allowing for the identification of the dominant peak frequency and derivation of a wave height characteristic of the total energy in the wave record.

At the end of the module, students were individually assessed by means of a report submitted based on their analysis of a synthetic water level record. To minimise “piggy backing”, each student’s synthetic wave record was randomly generated using their student number as a seed and so no two students analysed the same data set.

As the tools developed in this module were needed for the following two projects this was perhaps the most intensive in terms of hands-on guidance needed for students. Whilst they have been introduced to Matlab in an earlier course in their degree, many required refreshers on programming logic such as *for* and *while* loop structures and uses. The more intensive guidance in this module however saw a much more independent student cohort for the remaining two projects which applied the skills they had developed in this module.

Module 2: Wave energy dissipation by a porous breakwater

This module built upon the skills learnt in module 1 with the following specified learning objectives (1) understand and analyse the hydraulic performance of a breakwater under a range of different hydrodynamic conditions using a physical model and (2) evaluate an existing predictive formula using experimental observations.

Porous breakwaters are one of the most widely used coastal protection structures worldwide. They are employed to stabilise river entrances, act as a last line of defence against erosion and to protect boat harbours from wave energy. This project examined the transmission of wave energy through a porous breakwater (see Figure 1) and in particular how different wave characteristics (height and period) influenced the extent of transmission.

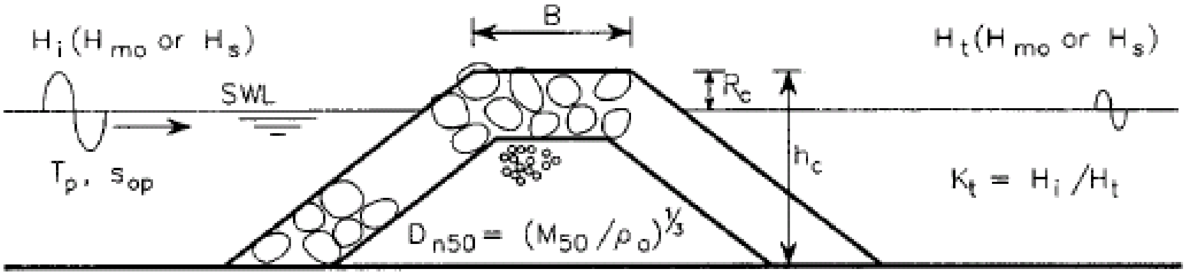

Figure 1: Governing variables related to breakwater wave transmission (van der Meer & Angremond, 1991)

During the laboratory session, the water level data collection was automated with pressure sensors and so the students were free to concentrate on observing the wave transmission at the structure. This aim of the guided observation session was for students to take notes and think about the physical processes occurring so that when it came time for them to analyse and discuss the data they had a strong foundation to work from.

The data analysis aspect of the project was then to analysis water level data from in front of and behind the breakwater so as to determine the experimental wave transmission coefficient,

$$C_t = \frac{H_t}{H_i} \qquad \textbf{(1)}$$

where H is the wave height and the subscripts t and i respectively denote the transmitted and incident values.

For the last part of the project, students were required, as a minimum, to compare their experimental value with the prediction of van der Meer and Angremond's (1991) empirical design formula,

$$C_t = \left(0.031\frac{H_s}{D_{n50}} - 0.24\right)\frac{R_c}{D_{n50}} + b \qquad \textbf{(2)}$$

where H_s is the significant wave height, D_{n50} is the size of the breakwater units, R_c is the elevation of the breakwater crest relative to the still water level and b is an empirical parameter which is a function of structure geometry and wave parameters.

To facilitate further development of team work skills, the data analysis and report writing were collaborative between groups of 2 or 3 students.

In order to encourage additional independent research from the students, they were encouraged to look for and evaluate additional design formulae from the literature. As a carrot for the students, this aspect was made one if the minimum requirements in the assessment criteria for a High Distinction grade.

Module 3: Surf zone wave transformation

This module built upon the skills learnt in module 1 with the following specified learning objectives (1) understand and analyse the transformation of waves through a surf zone under a range of different wave conditions using a physical model and (2) evaluate an existing predictive model (Alsina and Baldock, 2007) using experimental observations.

The nature of the wave climate the near shore is very complex but understanding is fundamental to nearly all coastal engineering problems/projects including sediment transport and hence coastal erosion modelling, storm surge modelling and coastal structure design. In this project, a 1 in 50 scale model of a typical Gold Coast near shore seabed profile was installed in the wave tank and pressure sensors were used to measure the water level fluctuations at numerous locations inside and outside of the surf zone (ie before and after wave breaking). From this data set students were able to observe and quantify the influence of wave breaking on the near shore wave climate and in particular examine the associated energy dissipation.

In order to further develop student understanding of this process they were asked to use their experimental data to evaluate to parametric wave transformation model based on the conservation of energy principle applied to the control volume shown in Figure 2,

$$\frac{dE_f}{dx} = -D_E \qquad \textbf{(3)}$$

where E_f is the wave energy flux and D_E is the wave energy dissipation (due to breaking) which is usually parameterised based on the Rayleigh distribution.

In introducing the theoretical background to this topic I experimented by firstly providing the students with the relevant paper describing the model with the instructions to read it and collate a list of questions to be asked at the next workshop session. Sadly this was somewhat of a failure as only 2 of 29 students asked questions despite my best efforts to get the others involved.

Again the laboratory session was used as an observation session and the data analysis and coding up of the model was undertaken during the supervised workshops.

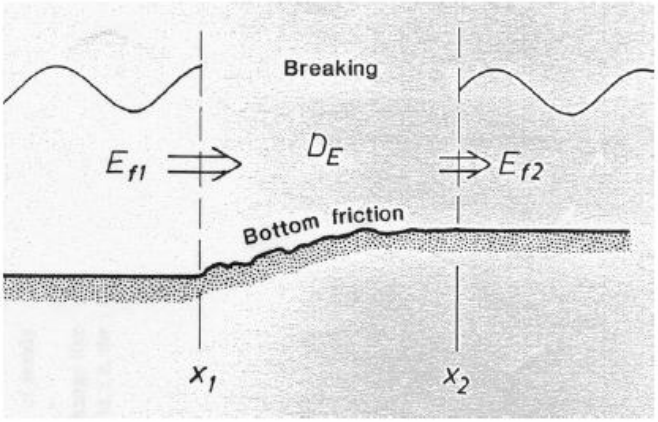

Figure 2. Control volume for the conservation of wave energy during wave breaking (Nielsen, 2009)

Student Assessment: Report writing skill development

Whilst report writing is entrenched throughout the students' degree, the project/RBL approach provides another opportunity to develop this skill therefore the method of assessment with each of the above modules was via submission of a technical report. Rather than relying existing skills, a conscious effort was made to clarify with students what the submission expectations were. This was achieved by providing a report structure skeleton with guiding questions for students that focussed on critical evaluation and discussion of their work. This was re-iterated verbally on several occasions both to the class and to individuals as required and, if students wanted, feedback would be given on draft reports prior to submission.

Student Evaluation

To assess how effective the introduction of the RBL approached had been in engaging students, a combination of random informal discussions with students during the course and a formal evaluation survey at the end of the course were employed.

Results and Discussion

Figure 3 and Table 1 summarise the student responses to the following course evaluation statements:

S1. This course was well-organised.

S2. The assessment was clear and fair

S3. I received helpful feedback on my assessment work

S4. This course engaged me in learning

S5. The teaching on this course was effective in helping me to learn

S6. Overall I am satisfied with the quality of this course

S7. I learned from collaborating with other students on assessment tasks

S8. My skills in analysis and problem solving increased as a consequence of doing this course

S9. The course helped me to improve my skills for presenting my ideas and/or results in a written report

In addition, Table 1, provides the corresponding university level Rating Interpretation Benchmark (RIB) rankings which is a comparison aggregation of courses/classes in the same Group/Faculty and Course/Class size bracket (21-50 students in this case).

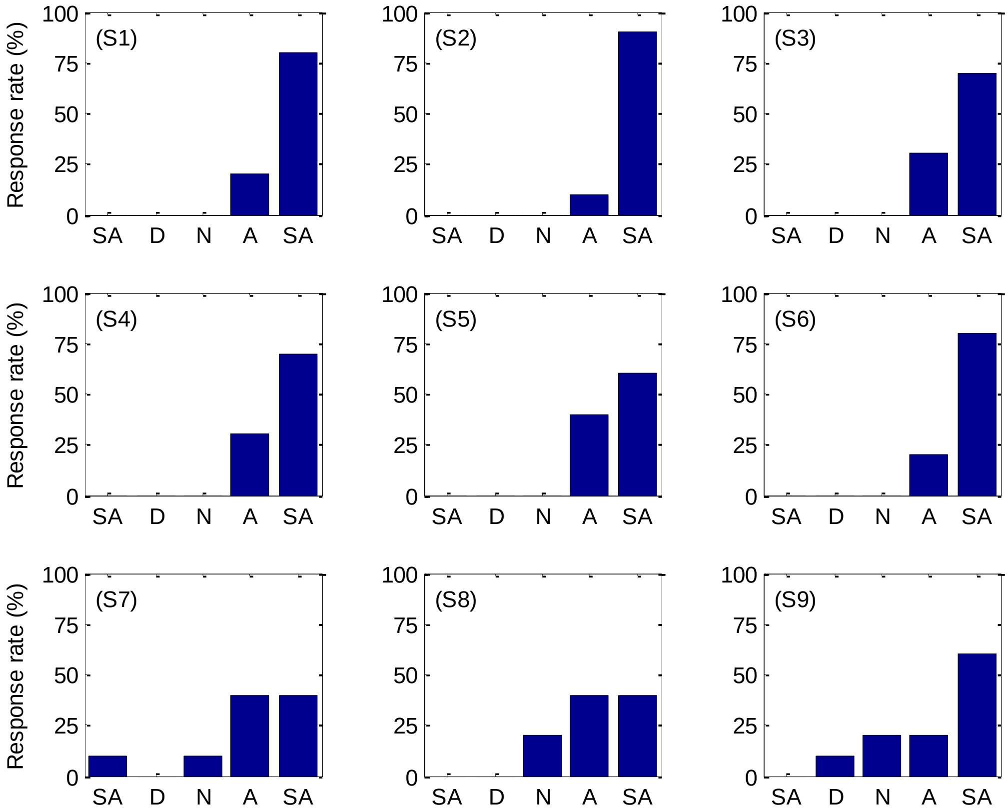

Figure 3: Student responses to the following course evaluation statements listed above. The horizontal axis corresponds to SA = strongly agree, A = agree, N = neutral, D = disagree, SD = strongly disagree

For all but two of the statements, the course RIB ranking was high which places it in the 75th percentile of university courses in the same size bracket therefore indicating that, overall, the course was well received by students. There was strong agreement that the course was well organised, had clear and fair assessment, gave good feedback, was engaging and had effective teaching.

Less conclusive was how students perceived how the course contributed to the development of their generic skills namely, collaborative group work (S7), analysis and problem solving (S8) and report writing (S9). Further insights into student perceptions in these areas can be gleaned from some of the qualitative comments from students. Some described how they enjoyed the group work aspect as it allowed students to "*work to their strengths and have others help them with their weaknesses*" whilst others commented that "*One thing of concern is that it is possible to get through this course without doing anything. If you join a group, effectively someone else could write up the whole report*". An obvious improvement to respond to the latter comment will be to either (a) have students write up their own report or

(b) have students designated particular sections and/or introduce a peer assessment scheme.

Table 1: Summary of mean evaluation scores (out of 5) for student evaluation of the course in comparison with university level RIB rankings (RIB = Rating Interpretation Benchmark is a comparison aggregation of other university courses in the same Group and size bracket)

Evaluation Statement	Mean	RIB (25%)	RIB (75%)	RIB Rank
S1 - This course was well-organised.	4.8	3.5	4.3	High
S2 - The assessment was clear and fair	4.9	3.5	4.2	High
S3 - I received helpful feedback on my assessment work	4.7	3.3	4.1	High
S4 - This course engaged me in learning	4.7	3.6	4.3	High
S5 - The teaching on this course was effective in helping me to learn	4.6	3.6	4.3	High
S6 - Overall I am satisfied with the quality of this course	4.8	3.5	4.3	High
S7 - I learned from collaborating with other students on assessment tasks	4.0	3.8	4.1	Med
S8 - My skills in analysis and problem solving increased as a consequence of doing this course	4.2	3.4	3.8	High
S9 - The course helped me to improve my skills for presenting my ideas and/or results in a written report	4.3	4.3	4.4	Med
S10 - Overall, how effective was this course in helping you to learn?	6.3/7	4.8/7	5.8/7	High

Qualitative comments

The following qualitative comments provide some additional insight into what aspects of the RBL approach the students found useful in helping them learn. On the positive, some students appeared to engage well with the research aspect of the course, the staged modules increasing in complexity through the course. On the negative, some students cited the piggy backing in the group work to be an issue as was difficulty reading a (moderately advanced) theoretical paper on their own. One student commented that they would prefer more lectures and smaller assignments like “normal” courses indicating that the RBL approach is not for everyone.

Table 2. Qualitative student comments in response to the question: *What did you find particularly good about this course?*

- Interesting layout with use of Matlab. Labs were interesting and raised some interesting questions that were interesting to research. Course helped me develop and practise my research skills, something that will be useful in the future.
- I was very happy with how this course was ran. The teaching style was effective in my understanding. By asking us to read the literature beforehand and come to class with questions in my mind was very good. Furthermore the class was good, enabling us to ask questions.
- I enjoyed the layout of the 3 modules, where the next one is slightly harder than the previous. The topics were extremely engaging and I found module 2 and 3 interesting.
- well organised, enjoyable to learn and overall taught very well, great feedback and assistance from the teacher, a great course to get students minds working, improve analytical skills and Matlab skills, very helpful course for data analysis, reporting and researching skills (helpful for future)
- The assignment based structure was excellent as it allowed for research into other areas of coastal engineering where students could engage in their style of learning at their own pace. The labs were interesting as they applied to real world situations and encouraged research. No exams also puts the stress levels down in November for students!

- I find that assessment, such as assignment investigations, are a much more effective way of learning. Without exams for this course I feel I have learnt a lot more about coastal engineering rather than cramming knowledge to be tested on which doesn't happen in the real world.

Table 3: Qualitative student comments in response to the question: *How could this course be improved?*

- A little bit more like a "normal course" with a few more lectures covering theory and smaller assessment items.
- One thing of concern is that it is possible to get through this course without doing anything. If you join a group, effectively someone else could write up the whole report... Maybe make the reports individual? That way everyone is forced to write up something. Maybe make the matlab scrip group work but the final report individual. That would get rid of the lazy people that get through doing nothing / minimal work.
- When you tried to get us to read AB07's paper then ask questions from that, I did read it and tried to follow but I did not understand what the paper was about at all and in particular could not work out the goal the paper was trying to achieve. Maybe if you posted some notes 'translating' the paper it may work better.
- Possibly more hands on work. For example designing more experiments and even getting out into the field and recording real data in a beach environment. Otherwise I found this course to be an effective approach for learning

Comparison with previous offerings

Although it is noted that previous offerings of this course had similar but not identical content (e.g. the 2011 RBL model covered less material but went in to more depth), it is interesting to view the comparison of the overall perception of students on how the course helped them to learn. All offerings had above average scores perhaps indicating that students are already somewhat engaged with the content regardless of the delivery method which is plausible given the course is an elective and students have chosen out of interest. The 2011 RBL offering however does shift towards the “excellent” response indicating that this approach has improved student engagement.

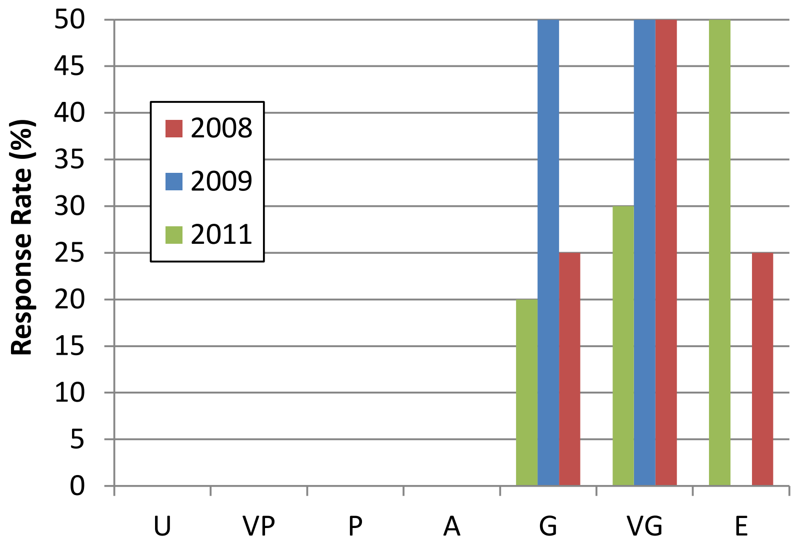

Figure 4: Comparison of student response to the evaluation question, “*Overall, how effective was this course in helping you to learn?*” from different course offerings (E = excellent, VG = very good, G = good, A = average, P = poor, VP = very poor, U = unacceptable)

Conclusion

The introduction of a research based learning approach to an undergraduate coastal engineering elective course was well received by students who indicated it engaged them and improved their understanding of the field and improved their generic data analysis and report writing skills in the process. Qualitative comments from students indicate that they enjoyed the freedom to undertake independent research engagement and that the interactive and open student/supervisor model adopted in the workshops worked well. They did however indicate some issues regarding lazy students being carried by groups and suggested a further improvement of having a field work based module. Whether or not the RBL approach is better than the traditional “chalk and talk” method is inconclusive due to differences in course content (quantity and type) but there are indications that students perceive the RBL approach to be more effective in helping them learn.

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Acknowledgements

I would like to thank Mr Geoff Turner, Mr Ian Underhill and Mr David Bellchambers for their help in constructing and deploying the scale models in the tank and also the students for their often fruitful and engaging discussions during the workshops.

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