Encouraging students to 'think as biologists': independent field-based projects and peer assessment as a deep learning strategy

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Based on criteria of contextual factors that encourage a deep approach to learning, an independent field-based activity for students of behavioural ecology was created. The project was designed in such a way as to allow responsible choice in the method and content (animal species) of study, involved posing questions and problem solving, and modelled the process of conducting and publishing the results of research. Results from collection of quantitative data on students' perceptions suggested that the learning context created through the activity encouraged problem solving, provided appropriate feedback, had clear aims and goals and was constructed in a fashion that allowed flexibility and responsible choice. Students' perceptions of their orientation to learning were consistent with attributes of a deep-learning approach. Students agreed that the project encouraged learning for understanding, engagement, confidence and self-efficacy, and personal growth. To address the problems of obtaining insufficient feedback during the writing of a scientific manuscript based on the project, a peer assessment component was introduced modelling the scientific publication process. Providing feedback to peers helped students critically reflect and identify the important attributes of a paper suitable for publication. Receiving written feedback from peers also allowed reflection and modification of writing and the interpretation of findings.

The 'deep-learning' approach

There is much literature to suggest that students' concepts of learning and the contexts within which learning takes place influence their overall approach to learning (Marton 1988; Ramsden 1992; Biggs 2003). A deep approach to learning is characterised by an intention to understand, focussing on the concepts applicable to solving problems, relating previous knowledge to new knowledge and having an internal or intrinsic motivational emphasis. Conversely, a surface approach is characterised by an intention only to complete task requirements, memorising for assessment, associating facts and concepts unreflectively and an external or extrinsic emphasis.

Accordingly, deep learning contexts provide opportunities for learners to navigate their own independent learning path, and the opportunity to exercise responsible choice in the methods and content of study. An appropriate environment for deep learning should provide continuous student feedback and encourage the application of acquired theory, concepts and knowledge to solving new problems. Activities which are 'deep' encourage an internal emphasis, and intention to understand rather than just completing task requirements (Ramsden 1992; Biggs 2003). Students who adopt a deep approach have been shown repeatedly in the literature to gain superior learning outcomes (Ramsden 1992).

Creating an activity in ecology which fosters a 'deep' approach

Traditionally, the practical field-based components of ecology courses at the tertiary level are content-centric and have focussed on skill acquisition in prescribed activities with little flexibility or autonomy. Based on the criteria of Ramsden (1992) of contextual factors which encourage a deep approach to learning, an independent field-based activity in behavioural ecology was created which

not only involved working independently on a field-based project, but was constructed in an 'open-ended' fashion to allow responsible choice in the method, content of study and degree of engagement. Continuous feedback was provided and together with the previously mentioned factors, it was hoped a superior learning experience for students was created. An authentic inquiry approach was adopted that focuses on the process of research in the biological sciences. The activity was structured to foster an incremental development of student understanding encouraging students to think like a scientist (as opposed to how to complete task demands or 'do the experiment'), by situating abstract concepts in relevant and authentic contexts.

It is hypothesised that if the learning activity is constructed in a way that accommodates these factors, students will adopt a deep-learning orientation characterised by evidence of learning for understanding, engagement and enjoyment, independence and ownership, confidence and self efficacy, and finally change and growth.

A 'blended learning' context to encourage a deep approach

The independent, field-based research project involved observing the behaviour of an animal species of the student's own choice under field conditions (Rise 2000). On the basis of information gained from an ethogram and time budget, with reference to the literature, students were required to create and test a hypothesis that was observable in the field (i.e., not a manipulative experiment). The hypotheses, experimental design, sampling strategy, data collection and analysis were all decision points for students with minimal imposed boundaries.

Students enrolled in a third year undergraduate offering in ecology undertake the project as part of a Bachelor of Environmental Science or Bachelor of Science program at the University of Newcastle, with class sizes ranging from 30-40 students.

An initial briefing session was run during the first laboratory class. This session outlined safety procedures in the field, ethical considerations when observing animals, instructions on how to compile an ethogram and how to collect data suitable for the calculation of a time budget.

An on-line asynchronous Internet based discussion forum (using the *Blackboard* platform) was created where students could post messages relaying specific problems or questions arising while conducting their projects. Feedback from both staff and peers on this forum was available for the whole student body to access. A number of optional face-to-face workshop sessions were also available for students to discuss their project progress, experimental design and specific issues with academic staff. In 2003 a formal summative assessment consisted of a written report, in the format of a journal article that would appear in the literature, with the journal *Animal Behaviour* used as a template.

To address student difficulties in the preparation of a manuscript for a scientific journal and to obtain greater feedback during the writing process, the peer assessment component was added in 2004. The peer review process served a dual function: to develop the skills of critical peer review and obtain further formative feedback on preparing a scientific publication through peer review. The peer review process was a requirement for students, though students were encouraged to approach staff if they were not comfortable with the peer review process, and alternatives were offered, i.e., feedback on draft from staff.

Students were provided with a paper published in *Animal Behaviour* (MacFarlane and King 2002) as a model example. The students were also provided with the instructions to authors from the international journal *Animal Behaviour*. Anonymous draft papers meeting these specifications were submitted to the lecturer and then redistributed anonymously to a peer with *Animal Behaviour's* instructions for reviewer guidelines. No student names appeared on manuscripts, only student identification numbers. Students were asked to critically review the paper and indicate its suitability

for publication based on these assessment criteria. Anonymous reviews from the MacFarlane and King (2002) paper during its publication were provided as an example as was our letter to the editor responding to comments.

Workshop sessions were conducted on topics such as preparing a manuscript for publication and peer reviewing a manuscript. Students received anonymous comments from a peer and were able to make changes, or challenge reviewer criticisms by letter, and then resubmit the final paper to the Editor (who in this case was the lecturer responsible for the course) for final summative assessment. Students could obtain individual help with assessing their peer's paper and answering their peer's comments on their own paper. Student evaluation of the activity for both years was conducted using quantitative questionnaires (Likert Scale) to access perceptions of learning context and orientation. Average responses between cohorts were analysed via chi square analysis.

Creating an appropriate context for learning

As would be expected, students with differing pre-existing skills, academic ability and prior learning experiences engaged in the activity at different levels. Some completed task requirements at the minimum standard expected, while others produced exceptional work of a publishable standard, often testing complex hypotheses. Indeed one student from the most recent cohort has undertaken to publish her work in a national referred journal. Flexibility and choice regarding the nature of hypotheses tested also meant that all students benefited by gaining a sense of the scientific method at project completion yet the activity provided enough scope to challenge the highest achievers.

Student feedback from the first cohort indicated perceptions of contextual factors and learning orientations consistent with a deep-learning approach. The majority of the student cohort either agreed or strongly agreed that the learning context created through the activity encouraged problem solving (73% agree) and provided appropriate feedback (appropriate assessment 59% agree, constructive feedback 77% agree, beneficial feedback from students 63% agree, and sufficient assistance, 64% strongly agree). Students felt the project had clear aims and goals (70% agree) and that the project was constructed in a way that allowed flexibility and responsible choice (74% strongly agree) (Table 1). In other words, there was close alignment between the curriculum, the blended methods used to facilitate learning, the assessment procedures employed and the climate that was created in which the learning took place, which Biggs (2003) believes is crucial in fostering deep learning.

Indicators of a 'deep-learning' orientation

Students' perceptions of their orientation to learning were consistent with attributes of a deep-learning approach. Students reported that the project encouraged learning for understanding (61% agree); engagement and enjoyment (interesting 50% strongly agree, doing more than required 50% strongly agree); independence and ownership (working independently 57% strongly agree); confidence and self efficacy (73% agree); change and growth (80% agree) (Table 1). Independently conducting field research, designing and testing a hypothesis and obtaining critical academic advice and peer feedback rather than conventional instruction, also promoted a greater sense of self efficacy, satisfaction, achievement, pride and confidence. Most importantly, many students felt that they were conducting the activity and testing the hypotheses generated because they truly sought to 'understand' what they were observing, not because it was simply a task requirement that had been imposed on them. Students reported a sense of change and growth through working independently in problem solving context and felt more equipped to transfer these acquired principles to new situations.

Peer assessment: modelling the publication process

Feedback from the 2003 cohort suggested insufficient feedback was available during the writing of a scientific manuscript based on the project. To respond to this, we introduced a peer assessment component in 2004 modelling the scientific publication process. Perceptions around deep-learning outcomes were consistent between the two cohorts. Chi square analyses suggested no significant differences in average response distributions for the same dimensions between the two cohorts (2003-2004) ($\chi^2 = 4.63$,df =3 p =0.20)(Figure 2). Introducing a peer assessment component immerses students in the activities of a professional research scientist and has a number of additional benefits. Providing feedback to peers helped students critically reflect and identify the important attributes of a paper suitable for publication in terms of structure, content and presentation. Receiving written feedback from peers also allows reflection and modification of existing schemata around writing and the interpretation of findings (Phye 1989). Peer assessment allows students to make comparisons of their work with others and for some can provide a useful stimulus for improving quality (Billington, 1997). Peer feedback had the added benefit of increasing the quality of final manuscript submissions. The distribution of grades reflected a greater level of understanding the previous cohort, the peer assessment approach increasing both mean and modal scores for the activity. Final assessment ranks for the activity in the 2004 cohort were higher on average and mode than 2003 (2003, n = 77, mean = 66.6%, SD = 10.4%, mode = 60%; 2004, n=61, mean = 73%, SD = 15.3%, mode = 87%).

Despite these benefits, reviewing the work of peers challenges some students; some felt ill-prepared to comment on the work of others, while still others felt uncomfortable with the responsibility of providing critical feedback. Student reviews tended to communicate the general overall quality of papers and largely reflected the relative rank via academic appraisal, a finding consistent with the literature on peer assessment (Billington 1997). A real issue, however, was the variable quality of peer feedback among the cohort, from detailed thoughtful critical appraisal, to scant, superficial comments on punctuation and grammar. This raises an equity issue for final submissions where students hope to obtain valuable feedback to improve the quality of their final manuscript for summative assessment purposes and causes some dissatisfaction. Involuntary participation in peer review coupled with the difficulty of maintaining total anonymity in small groups may also explain why some students only commented on other students' spelling and punctuation.

Table 1. Questionnaire responses from 2003 cohort, N=23.

QUESTION	**SA**	**A**	**D**	**SD**
I enjoyed the challenge of working independently	**57**	43	0	0
The project helped me develop skills relevant to my future career	39	**57**	0	4
The project gave me the opportunity to exercise choice	**74**	26	0	0
The aims, goals, and instructions of the project were clearly defined	17	**70**	13	0
The assessment of the project was appropriate	32	**59**	9	0
Feedback on the project was constructive and helped me learn	23	**77**	0	0
There was sufficient assistance when required during the project	**64**	31	5	0
I have learned to feel more responsible for my own learning	**48**	48	4	0
Feedback from other students on my project helped me learn	14	**63**	23	0
The project allowed me to foster my own individual interests	30	**66**	4	0
I was able to relate what I observed to knowledge gained	36	**59**	5	0
I found I did more than required for the project, because I enjoyed it	41	**50**	9	0
The study encouraged me to understand and find meaning	39	**61**	0	0
I changed as a result of the project	14	**73**	13	0
The way the project was designed encouraged problem solving skills	23	**73**	4	0
I felt I had sufficient background knowledge to attempt the project	18	**59**	18	5
I found surveying the literature assisted	**52**	39	9	0
I found the project interesting and stimulating	**50**	50	0	0
I feel I have changed and developed through doing the project	9	**80**	11	0
Average Response	35.8	**57.0**	6.7	0.5

Table 2. Questionnaire responses from 2004 cohort with addition of peer assessment component, N=33.

QUESTION	SA	A	D	SD
I enjoyed the challenge of working independently	24	**76**	0	0
The project helped me develop skills relevant to my future career	39	**57**	4	0
The project gave me the opportunity to exercise choice	**58**	42	0	0
The aims, goals, and instructions of the project were clearly defined	15	**76**	9	0
The assessment of the project was appropriate	16	**81**	3	0
Feedback on the project was constructive and helped me learn	10	**74**	13	3
There was sufficient assistance when required during the project	21	**67**	12	0
I have learned to feel more responsible for my own learning	38	**62**	0	0
Feedback from other students on my project helped me learn	12	**75**	9	3
The project allowed me to foster my own individual interests	36	**52**	12	0
I was able to relate what I observed to knowledge gained	22	**75**	3	0
I found I did more than required for the project, because I enjoyed it	12	**72**	16	0
The study encouraged me to understand and find meaning	23	**74**	3	0
I changed as a result of the project	12	**82**	6	0
The way the project was designed encouraged problem solving skills	21	**76**	3	0
I felt I had sufficient background knowledge to attempt the project	9	**88**	3	0
I found surveying the literature assisted	38	**56**	6	0
I found the project interesting and stimulating	28	**72**	0	0
I feel I have changed and developed through doing the project	6	**85**	9	0
Hypothesis formulation and testing involved more problem solving skills	33	**67**	0	0
Hypothesis testing was the most enjoyable part of the project	4	**72**	24	0
I learnt a great deal about the publishing process through peer review	25	**72**	3	0
Reviewing others work assisted my own learning/improved my paper	18	**73**	9	0
Obtaining peer feedback assisted improved my paper	16	**72**	6	6
Average Response	22.3	**70.8**	6.4	0.5

Ways forward: further 'blending'

The independent project evolves each year in response to student evaluation and future delivery will incorporate a number of modifications in an attempt to address some of the aforementioned problems. Providing exemplars of past student work (with author's permission), where students have addressed complex ideas may 'raise the bar' in terms of encouraging students to read more literature, contemplate the behaviours they are observing in a more critical fashion, and generate hypotheses which address the adaptive and/or functional nature of behaviours in the natural world.

Stressing the importance and benefits of formative assessment and feedback and assigning a summative weight to the peer assessment component may encourage students to take more time and effort in the critical appraisal of a peer's manuscript. Initiating a multiple perspectives approach, whereby each student reviews two peers' manuscripts anonymously may assist in improving the probability of an individual receiving quality feedback on their own manuscript.

A blended learning approach was applied, combining various delivery methods (laboratory sessions, theoretical instruction, online collaboration, independent fieldwork) to facilitate student learning during the activity. We aim to further 'blend' in future delivery by moving the peer assessment process to an online peer review system via the *Calibrated Peer Review* instrument (see http://cpr.molsci.ucla.edu/) which reflects current professional practice of many international journals. Electronic exemplar papers will be provided for students to gain skills in critical peer review (calibrating the process). Online video-streamed examples of animals in the field and exemplar time budgets for these video streams will also be created to move laboratory skill acquisition to an online forum.

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