Exploring sustainability in the context of land reclamation: an exercise for environmental management trainees

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Abstract: Reductions in the fieldwork component of many environmental curricula mean that graduates have less practical experience. This paper attempts to compensate by developing a short, intensive, highly structured field exercise that aims to connect classroom theory to field realities in the context of the management of reclaimed coal-land. A self-paced field trail guides learners, first to examine land degradation processes in detail and then to tackle larger sustainability issues. The problems that learners encounter include difficulties in understanding the mind-sets of either landscape designers or land users and of comprehending landscape process dynamics. Nevertheless, learners value the first hand experience, the realisation that real-world answers are not always simple, that prior learning is essential to effective field interpretation, that teamwork is a problem-solving tool and that these skills require 'practice'. Learners who score well in fieldwork also scored well in class quizzes, spoken presentations, essays, other field projects and formal examinations.

Keywords: land reclamation; education for sustainable development; ESD; problem-based learning; PBL; surface coal mining; training environmental managers; Wales, UK.

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1 Introduction

One of the problems of education for sustainable development in the applied environmental sciences is that, in the search for technical skills and detailed knowledge, learners frequently fail to develop an ability to read the landscape as a whole. In the context of land reclamation, for example, different learners may have awareness of the development of vegetation and ecology, of soil quality, an appreciation of drainage structures, land-forming or landscape aesthetics and even, occasionally, the way the landscape will affect and interact with its future land users and neighbours. However, it is quite unusual to find a learner who can combine all such considerations into a single complete picture (Severočeské Doly a.s., 2006; Haigh, 1996). The problem is fundamental to a classroom-based education that develops subjects in discrete topical packages and so emphasises theory ahead of practical reality. The solution, of course, is to immerse learners in some real-world problems and help them construct their bigger picture through guided learning (McEwen et al., 2003). Sadly, most western colleges have placed a downward pressure on field work, which office-bound administrations regard as an expensive, marginal and legally hazardous activity. So, the problem for the educator is to find a way of maximising the educational benefits that may be obtained from any limited opportunities for fieldwork that survive.

This study describes experience from a single day, problem-based learning (PBL), fieldwork exercise (Pawson et al., 2008, 2006; Bradbeer, 1996). It is developed in the context of an advanced undergraduate course in 'Environmental Management', which is part of a multidisciplinary modular course at Oxford Brookes University, UK. This course, which enrols around 45 learners each year, has run in its present form for three-years, with the field trip as part of its core. Its function includes preparing learners to conduct their own independent assessments of the qualities and sustainability of reclaimed land in the context of a subsequent field practical week in North Bohemia, which includes projects conducted in cooperation with industry in the form of Severočeské Doly (North Bohemia Mines company) (Wlam and Jelenik, 2005; Severočeské Doly a.s., 2006). However, the field trip itself, a self-directed field trail, inherited from an earlier course on 'soil conservation', has run in the same location, the Blaenant land reclamation, near Brynmawr, Blaenau Gwent, South Wales for almost 20 years (Haigh, 1996; Higgitt, 1996). During this time, in sequential annual revisions, the exercise has served more than 600 participants, including about 70 that continued to further studies on the North Bohemia sites.

This 'Blaenant field trail' is a short, intensive, highly structured, PBL field exercise that aims to connect classroom theory to field realities in the context of the management of reclaimed coal-land by engaging learners in proposing the causes and solutions of problems that affect its sustainability. The self-paced field trail guides learners, first to examine land degradation processes in detail and then to tackle larger land management issues. The learners' task is to solve the problem of how to manage these reclaimed coal lands in order to sustain and enhance their quality and economic utility. This paper evaluates their performance by considering records from the collected experiences and outputs. It employs three main sources of evidence. First, it uses learner responses to course evaluation questionnaires, especially a set of questionnaires that examine the exercise from the perspectives of PBL. Second, it explores learner responses to questions in the field-trail work-books and to quiz question responses in a post-experience class quiz. Third, it uses evidence from a sequence of seven videos and one virtual field trail

(VFT), produced in different years by teams of students, who took on the task of providing answers to the questions in the field guide for their peers.

2 Background

PBL aims to translate the theoretical information that learners encounter in classroom sessions into practical knowledge by solving real world problems. In this case, the problem involves the recognition, diagnosis and treatment of land degradation and sustainability issues in the field (Mills, 2004; Pawson et al., 2008, 2006; Bradbeer, 1996). In the current study, the field trail emphasises technical erosion control and the validity of engineering solutions. However, it also encourages learners to consider the land user and solutions based on land management. The exercise is based upon a field-trail workbook. This consists of a map that guides learners through a series of sites, where they tackle questions that attempt to encourage them to examine, critically and in detail, the symptoms of environmental change and management problems manifest in the soil, water courses, vegetation, engineering structures and land uses found on typical reclaimed coal-lands of the case study region in South Wales. Of course, while coal production in the European Union is in decline, it still exceeds 400 Mt. per year, virtually all through surface mining (Mills, 2004). Consequently, Europe contains a substantial and expanding area of reclaimed coal lands of different qualities. Equally, the problems of reclaimed opencast coal lands share similarities with those many other engineered lands, including those created through other types of mining, road construction and other major engineering projects (Haigh, 2000). So, this is a useful exercise for those training to become environmental managers.

Figure 1 Blaenant land reclamation site, Wales: 'Outlet C' in 1982

The field trail has two halves. The first runs across the former Blaenant opencast coal mine, which lies on the upper convexity of the Clydach Gorge, a steep and exposed site.

This mine operated from the early 1970s and was reclaimed after 1978. Reclamation consisted of land forming, compaction of the mudstone and shale minestones and the application of a thin layer of topsoil, which was subsequently redistributed by erosion. Grass seeding and fertilisation provided a surface cover. The end result was a dense grass and moss pasture overlying a thin layer of applied topsoil above a highly compacted and largely impermeable layer of opencast spoils (Kilmartin, 1994; Haigh and Sansom, 1999). By 1981, the site was found to be suffering severe land degradation including loss of vegetation and gully erosion. It had also become the subject of litigation from downstream neighbours, who blamed the site for flooding. In response, the land was extensively reworked, reseeded in parts and new channel management structures installed, most notably a large concrete drain called 'Outlet C' (Figure 1).

In the mid 1980s, there was an extensive programme of forestation in fenced plots. The site was managed until 1988 and then either rented to farmers or returned to common grazing, mainly for sheep. Wire cutting by pastoralists affected several of the forestation patches, with the result that many trees were damaged or destroyed, but elsewhere trees survived and now cover substantial tracts. The site has also suffered mass movement, some creep of the surface soil cover and some slumping caused by the incision of site-margin channels.

The Blaenant field sites include seepage scars, which develop because of the perched water table developed above the compacted mine spoil subsoil and a quaking bog formed in a small hollow. Learners examine the evolution of artificial watercourses, where hydrologically flashy channels are affected by sedimentation and bank retreat of the applied topsoil layer (Kilmartin, 1994, 2000) and then drainage structures: contour drains, French drains, drop structures and concrete channels as well as the situation on the downstream site margins where hydrological control is passed to new land managers. The trail considers the land management issues connected to forestry and problems caused by trafficking, especially the ease with which wheels cut through the topsoil and ruts create channels in the impermeable subsoil. Finally, it leads the learners to consider safety and aesthetics, especially the problems created by vertical-sided deep concrete channels on land used by children and grazing animals (Figures 2 and 3).

Part 2 of the field trail crosses an adjacent 1990 reclamation of deep mine spoils in Cwm Llamarch, which demonstrates some variations on the management and erosion themes found on Blaenant. Here, unlike Part 1, the trail no longer uses detailed questions to focus each learner on the detail of each problem and structure but asks for broad assessments of the issues, the problems and the management solutions. The hope is that learners apply the approaches of Part 1 to their independent assessments of Part 2. However, the intellectual stepping-up that this involved causes learners to lose twice as many marks in this second part of the trail – although of course, they may also be getting tired and bowed down by the weather (traditionally: rainy, cold and with a driving wind) by the time they reach these later parts of the exercise.

'PBL' questionnaires asking participants to evaluate their PBL experience were handed out to all participants during the years 2005–2007. These asked questions such as what do you believe this exercise is about, what did you learn, what was good/bad about the experience, what was good/bad about the approach and would you like to do more of this kind of exercise? Ordinary course evaluation questionnaires, handed out to all course participants for every run of the exercise, asked learners to describe their experiences of the whole module.

Figure 2 Blaenant land reclamation site, Wales: 'Outlet C' – warning to parents (see online version for colours)

Figure 3 Blaenant land reclamation site, Wales: contour drain (with *Juncus.sp*) showing erosional breaching of the contour bund (see online version for colours)

3 Findings

In the 54 PBL questionnaires retrieved, 32 respondents wanted to do more fieldwork, just two did not. Thirty-one recognised that the exercise was about sustainable land management, 27 mentioned technical soil and erosion control and 20 mentioned land reclamation. Just one mentioned vegetation and two the place of the land users, even though these are prominent aspects of the trail and the class that preceded it. Only ten thought that they should be trying to diagnose future problems and propose new land management strategies. However, 43 thought the experience had improved their understanding and 38 their ability to apply a solution while 11 thought they had built skills in analysis and nine in team-working. The main benefits listed were gaining first-hand experience (31), connecting theory and practice (19) and thinking holistically about a problem and its solution (15). The main difficulties encountered arose from the need for prior knowledge and study (22), the observation that there were not often simple answers (21) and bad weather (14), although the first two encouraged learners to discuss and work in teams. Correlation analysis (Table 1) finds significant positive correlations between 'learning team-working' and recognising 'a need for prior knowledge'.

Typically, learners prefer not to work in teams, especially where this involves shared assessment. A remarkable feature of this problem-solving exercise was that the learners spontaneously formed themselves into teams. Two motivations seemed apparent. The first was a wish to pool prior learning, which for many was inadequate – they simply had not done sufficient study. The second was to gain some reinforcement for the answers and observations that they made as individuals – so the team helped boost self-confidence.

Table 1 Correlation analysis of student experience questionnaires (2005–2007)

Spearmans rho (sample n = 54)	*Improved understanding*	*Improved ability to apply solutions*	*Learnt teamwork*
Improved understanding		0.617 ($p < 0.0005$)	
Improved ability to apply solution	0.617 ($p < 0.0005$)		
Main problem: need prior knowledge			0.415 ($p = 0.02$)
Main problem: no simple answers			
Spearmans rho (sample n = 54)	*Learnt land management methods*	*Main problem: bad weather*	*Like to do more*
Improved understanding			0.409 ($p = 0.002$)
Improved ability to apply solution		0.327 ($p = 0.016$)	0.287 ($p = 0.035$)
Main problem: need prior knowledge	–0.327 ($p = 0.016$)		
Main problem: no simple answers		–0.366 ($p = 0.006$)	

Table 1 shows significant correlations between worries about the weather and the ability to find solutions as well as a negative correlation between the weather and recognition that there may not be simple answers. Positive correlations show that those learners who wanted more field work of this kind recognised that it improved their understanding and their ability to find solutions.

Review of the student videos and assessed work, both quiz returns and field trail workbooks, provided a rather different perspective. The most jarring elements were the errors. Some of these resulted from curious lapses, such as a failure to register that the whole landscape on reclaimed opencast coal-lands is artificial, less than a few decades old, and hence that it was entirely designed. Nothing about it 'had to be that way'. Everything was created from the mind of its designer and was the physical manifestation of their thoughts – only latterly modified by the (nicely characterised) 'wild-becoming' of natural processes (Devdarijani, 1954). However, very few learners managed to make the mental leap necessary to understand that it may have been worth wondering what the designers were hoping to achieve, for whom and for what purpose. One of the questions most routinely fudged in the field trail workbook concerned the place one should focus first in the inspection of a land reclamation site. The answer is 'at the edges', especially the downstream edges, because it is here that the land passes beyond the designer's control and where any change in the hydrological or sediment regime will likely be expressed.

More seriously, these data emphasised that the one thing a short field experience cannot adequately address is the long term perspective needed to understand environmental dynamics. Although, in this case, the problem was somewhat addressed by the open-access series of student trail videos and the VFT, which collectively charted 20 years of changes. The fact remained that for these learners, if it was not raining on the day, they could not imagine the effects of rain. If a conduit was not flowing vigorously during their visit, they could not conceive that channel in flood state. If a part of the land was not vegetated, they were not able to imagine that it had ever been vegetated, even when surrounded by the field evidence. For most, their diagnoses and recommendations were based solely on what they could see on the day and they were unable to detect either the field evidence of change or to estimate its rate. The question remains open as to what extent this problem could be translated into poor recommendations on the part of inexperienced young professionals after graduation.

A further problem, familiar to all academics, was the selective blindness of the specialist. No matter that the learners had undergone a relatively broad education, the fact remained that those with special interests in engineering structures tended to be oblivious to the social processes affecting those structures. Those who had special interests in ecology saw the plants but ignored the hydrology and soils, while those who espoused a 'geographers' interest in landscape considered the aesthetics and the way it was being used, but ignored the techniques and functionality of its engineering. (The greatest flowering of this pathology was demonstrated by a project team investigating the loss of vegetation, who were discovered measuring soil pH on some steeply sloping de-vegetated land nearby, apparently oblivious to the fact that they were completely surrounded by motor-cycle tyre-tracks. Motor cycle wheeling was unexpected, so not included in their research design and not part of their investigation. Their report concluded that since the pH on land that had lost vegetation was significantly lower than that where it survived, the problem should be corrected by liming). The most common error in tests was a failure to consider the welfare of the land user. The warning notices set beside the concrete ditch of outlet C were ignored by 5/6ths of test respondents (Figure 2).

Another problem was that some admittedly lower performing learners resented being asked to connect what they had learnt in class or memorised from the textbook, with what they actually could see in the field. Indeed, some argued that they should not be expected to make such connections. For these learners, the goal was to pass a University course, which traditionally means memorising some work for a written test or writing a paper, all activities unrelated to applying this information to problem solving in the field. Problem solving, of course, favours learners who adopt deep learning strategies that involve comprehension and the understanding of principles rather than surface learners who simply commit course information to memory, without really understanding what it means (Ramsden, 1982).

Detailed analysis of work handed in for assessment found some additional common patterns in the errors. The first was error by association. Seepage scars, viewed from a distance might be mistaken for landslide crescents; it takes a close inspection to confirm that they are created by wash and not by slippage or animal burrowing. Many learners did not feel it necessary to inspect the feature closely and were content to identify the feature incorrectly from a discrete, clip-board wielding, distance. This error affected more than half of the learners who tackled this question. The second error was caused by poor preparation, all of those learners who failed to respond adequately to a question on drop structures also failed to recognise other types of water management structures – simply, they did not have the prior knowledge. Curiously, more than half of those asked, by a class quiz, to identify a contour drain and bund from a photograph from Blaenant (Figure 3) failed to connect the reality with the feature in the course notes, even in cases where they or perhaps a team colleague, had previously identified the same feature accurately in the field. In fact, there was a significant negative correlation between total marks for this quiz and the ability to identify the contour drain (rho = 0.431, p = 0.045), which again suggests a link with poor preparation.

4 Analysis of fieldwork and other assessment strategies

Questions have been raised about what such problem-solving fieldwork experience tests in learners relative to other conventional modes of assessment. Table 2 shows the correlations between marks scored in this fieldwork PBL exercise and the other modes of assessment used in the 'environmental management' course. These show that the marks won from the field trail work-book correlate most closely with those from class quiz tests of theory, which suggests that the fieldwork exercise does involve the use of a lot of immediate and memorised knowledge. They also correlate very strongly with the critical essay exercise, which involves the capacity to create a synthesis from diverse information. However, they correlate much less well with results from a team-based project, which involves the solving of a self-selected problem in either the laboratory or through field study. It is worth noting that there was no significant correlation between team project and quiz scores, which shows that these test completely different aptitudes.

In earlier years, the field trail exercise was an optional part of a more specialised course on soil conservation. Figure 4 and Table 3 display the correlations between marks for the field trail and other coursework components of this earlier module for the years 1999–2003. A product of less restrictive times, this course allowed learners to choose between an array of assessments, although it also contained a compulsory theory quiz and a formal essay examination in place of the critical review essay used by the later module. The course also allowed learners to contribute their own ten minute lecture on an assigned topic to the course as part of their studies ('DIY lecture') and undertake the Blaenant trail as a VFT rather than the real thing. The data, however, shows that there is no correlation at all between results from the VFT and those for the real thing. Instead, the VFT marks correlate positively only with scores from the class tests of theory and make a lone negative correlation with scores in the final examination. Real world fieldwork scores, however, correlate very strongly with scores for the DIY lecture, which may reflect the old truism that the best way of learning any subject is to try and teach it to others. In this case, the scores for the team project make no correlation with the fieldwork scores, which may reflect a greater emphasis on laboratory modelling rather than the field-based studies that dominant the successor course.

Table 2 Correlations between fieldwork marks and other types of coursework (n = 134; 2005–2007)

Spearman's rho	*Fieldwork*	*Theory quiz*	*Essay*	*Team project*
Fieldwork		0.279 (p = 0.003)	0.270 (p = 0.004)	0.207 (p = 0.021)
Theory quiz	0.279 (p = 0.003)		0.194 (p = 0.012)	0.048
Essay	0.270 (p = 0.004)	0.194 (p = 0.012)		0.273 (p = 0.001)
Team project	0.207 (p = 0.021)	0.048	0.273 (p = 0.001)	

Figure 4 Correlations between fieldwork and other modes of assessment in the earlier soil conservation module (see Table 3)

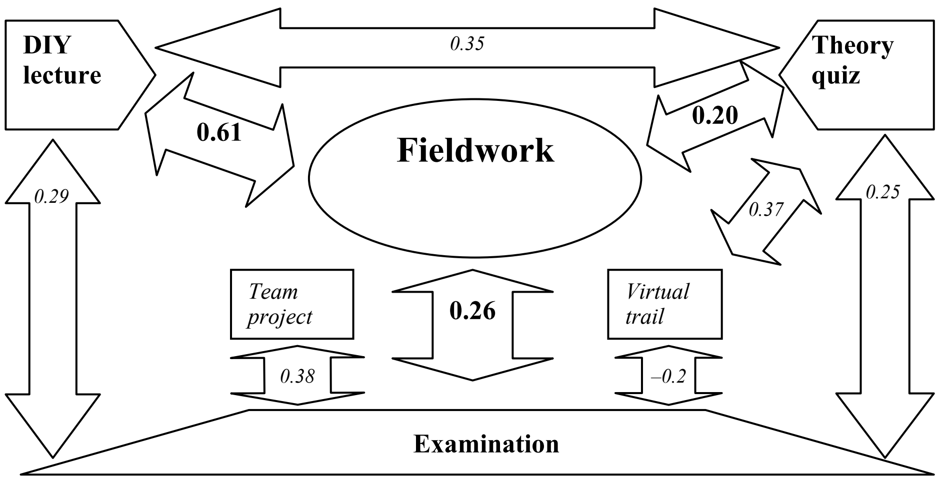

Table 3 Correlations between fieldwork marks and other types of coursework in earlier soil conservation module

Spearman's rho	*Fieldwork*	*Theory quiz*	*DIY lecture*
Fieldwork		0.197 (p = 0.025) (n = 99)	0.611 (p = < 0.0005) (n = 64)
Theory quiz	0.197 (p = 0.025) (n = 99)		0.354 (p = >0.0005) (n = 168)
DIY lecture	0.611 (p = < 0.0005) (n = 64)	0.354 (p = < 0.0005) (n = 168)	
Virtual field trail		0.373 (p = 0.001) (n = 67)	
Project			
Examination	0.261 (p = 0.016) (n = 69)	0.250 (p = < 0.0005) (n = 301)	0.290 (p = < 0.0005) (n = 146)

Spearman's rho	*Virtual field trail*	*Project*	*Examination*
Fieldwork			0.261 (p = 0.015) (n = 69)
Theory quiz	0.373 (p = 0.001) (n = 67)		0.250 (p = < 0.0005) (n = 301)
DIY lecture			0.290 (p = < 0.0005) (n = 146)
Virtual field trail			–0.202 (p = 0.050) (n = 67)
Project			0.375 (p =< 0.0005) (n = 139)
Examination	–0.202 (p = 0.050) (n = 67)	0.375 (p = > 0.0005) (n = 139)	

Note: Sample size = n

Source: Haigh (2007)

British-education-system traditionalists, will, of course, be pleased to note strong, significant, fairly uniform, positive correlations between the results in the essay-based, two hour, unseen examination and all the other modes of assessment, except the VFT. This reinforces the widely held doctrine that, if you can use only one form of assessment, the unseen essay examination is your best option. However, it is also worth noting that this test of learning correlates least well with the two fieldwork-based assessments, which require use of knowledge and deductive reasoning as well as broad theoretical understanding. Indeed, if you hold the memory-related theoretical quiz scores constant and recalculate the partial correlation between fieldwork and examinations the outcome is very far from significant (r: 0.12, $p = 0.35$), which shows that these techniques are probably assessing different aptitudes (Haigh, 2007).

5 Discussion

It is widely accepted that active learning strategies are the best way of developing the sustainable development knowledge and problem-solving skills that will be needed for the future (McLaughlan, 2007). Teichler (1998, p.8) comments that, while there are ever stronger demands on education from the world of work, more than ever the nature of what they want is blurred. However, practical problem solving abilities and being able to ‘think outside the box’ are key skills. In support of the UN Decade of Education for Sustainable Development, Fien (2006) stresses the need for holistic vision and prioritises the ability to evaluate uncertainty and the necessity for precautionary action. All of these aptitudes are engaged by PBL field exercises such as the one described here and others that seek to develop the concept of ‘the expanded classroom’ for experiential education (McEwen et al., 2003; Katula and Threnhauser, 1999). The main issue here is whether or not it is better to try and create this broad vision within each individual learner or to teach that learner to become used to working in multidisciplinary teams that collectively deploy the broad sustainability understanding needed by environmental professionals (Meehan and Thomas, 2006). In fact, the two approaches are not discrete and these results show that this kind of individual work has the side-effect of encouraging team-working as a voluntary strategy.

From an educational point of view, there remains a need to find out more about what affects useful learning and what role learners play in this process. Rickson (2001) concludes that more needs to be done to outline the learners experience at the point curriculum, teaching methods, assessment and learner aspirations intersect. Here, it is shown how different modes of assessment can be used to encourage learners to develop their own learning, accepting only that learners, in general, are sensitive to trying to increase their marks and tend to adopt mark winning strategies (Haigh, 2007). The study vindicates the ancient British tradition of setting written examinations but it also suggests that field-based problem solving is addressing skills beyond those that examinations can test. However, the learners own responses also emphasise that there is a limit to how much can be achieved by a single field experience and that the skills of field interpretation and holistic vision need to be reinforced by repetition. The PBL questionnaire responses show that, immediately after the event, learners were aware of what they needed to do to gain more marks from the experience and much of that involved preparation, better teamwork and focus. However, six months later, when the same students sought to apply their learning experience in the new context of an 'environmental consultancy' role-playing exercise undertaken in conjunction with an industrial sponsor, Severočeské Doly a.s. (2006), in the Czech Republic, while a greater appreciation of the technologies and a better team working was displayed, two problems persisted. These included inexperience, especially manifested as an inability to imagine the hydrological system in extreme conditions but, more seriously, a continued reluctance to consider the mental processes of the designer by, for example, reconstructing the calculations employed for the design of channels.

6 Concluding remarks

Increasingly, government planning agencies and commercial environmental consultancies employ graduates who have broad-based educational qualifications in environmental management or one of the environmental sciences. For reasons of cost and often administrative inconvenience, the fieldwork practical component of educational courses is increasingly skimped. As a consequence, more graduates leave higher education with less practical field experience. This can lead to major problems when they enter employment and make important decisions relating to environmental security or sustainable development planning. It also means that optimal use must be made of what little fieldwork remains in an educational program.

This paper has described an exercise that uses a short, intensive, highly structured, field study experience to help learners connect classroom theory to field realities. Set, in the context of the management of soils and drainage on reclaimed coal-lands in the uplands of South Wales, it explores two land reclamation projects: one a former surface coal mine and the second a mountain torrent formerly smothered in unstable, loose-tipped, deep-mine colliery spoils. The exercise engages a self-paced field trail that first introduces the learners to generic issues affecting the sustainability of reclaimed lands and then asks them to use their understanding to evaluate the same issues in a slightly different context on another site. The results highlight the problems that learners encounter during this first attempt to translate classroom understanding into field practice.

Sustainability diagnosis was inhibited by the learners' difficulty in understanding that reclaimed land is designed and so expresses a statement of purpose and also in comprehending the dynamic nature of the landscape or even imagining the operation of hydrological processes in conditions other than those current during their visit. They also found it hard to shed technical blinkers and to conceive the environment from the point of view of the land user. Nevertheless, most participants valued the first-hand experience the exercise provided and sometimes after the fact, appreciated that in the real world, the answers are not always simple, that prior learning is a prerequisite to effective field interpretation and that teamwork is useful method of solving environmental management problems. They also recognised that 'practice' would be needed to build skills in this kind of environmental and sustainability diagnosis.

Analysis of mark-sheets found that learners who scored well in fieldwork also scored well in class room objective quizzes, making class presentations, essays, other forms of field project and formal essay examinations. There was no correlation between the field trail scores and marks from an identical VFT, which linked only with the class room quizzes. Partial correlation analysis found that when these quiz data were held constant, the correlation between the field work and examination score disappeared, proving that the field trail was testing a different skill set.

In closing, PBL in fieldwork contexts adds a new dimension to the training of environmental managers that helps them ground-truth classroom theory and realise the value of prior knowledge and team-working in environmental diagnosis. However, the same students find it difficult to comprehend either environmental dynamics, envision environmental change or see through the eyes either of the landscape designer or land user. These skills require substantial experience, which cannot be delivered by an isolated field experience, although this can serve by alerting learners to the problem.

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