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A Research-Led, Inquiry-Based Learning Experiment: Classic Landforms of Deglaciation, Glen Etive, Scottish Highlands

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ABSTRACT *This paper reports an adaptation of a classroom-based, traditionally taught module to both facilitate field-based knowledge acquisition and contribute towards research. The module enabled students, through a combination of new research and co-learning, to achieve the original classroom-based learning outcomes. Students engaged enthusiastically with the research project, developing a deeper learning style as demonstrated by improved student performance and a sense of ownership of the learning experience. The study concludes that field-centred, inquiry-based learning draws heavily upon staff resources but is an effective means of facilitating teaching and research in tandem.*

KEY WORDS: Inquiry-based learning, glacial geomorphology, fieldwork, research-led teaching, undergraduate

Introduction—Research-Informed Teaching and Fieldwork in Geography

Recent literature has considered the relationship between research and different modes of learning in geography (e.g. Jenkins, 2000, 2003; Healey, 2005; Spronken-Smith, 2005). The nexus between teaching and research is often assumed to be a positive association, with excellence in research being claimed as an obvious link to excellent teaching (Jenkins *et al.*, 2003). This proposed direct connection between teaching quality and research is discussed and challenged by many (Brew & Boud, 1995; Race, 1995; Smith & Brown, 1995; Healey *et al.*, 2003; Jenkins, 2003; Jenkins *et al.*, 2003), in that direct evidence linking research productivity and teaching quality is limited (e.g. Hattie & Marsh, 1996; Marsh, 2007) and teaching and research have been perceived as being in conflict with one another (Gaskin, 2003; Marsh, 2007). It is more widely accepted that where research (which can be defined in many ways) is incorporated into teaching in a planned manner, then the potential for truly deep and reflective learning should be maximized; as Brew and Boud (1995) put it: "Teaching and research are correlated when they are co-related" (p. 272).

Theories of situation-based learning encourage student-centred research because constructivist forms of learning sit well with the Kolb learning cycle (Fry *et al.*, 2003).

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Garnett and Holmes (1995) contend that teaching, learning and research should exist symbiotically, with teaching informing research, and *vice versa*. Healey (2005) argues that students are likely to get the most benefit from research when they are actively involved in it. Research-based learning fulfils this purpose as it is primarily designed around inquiry-based activity, rather than the acquisition of subject matter (Griffiths, 2004). The fact that inquiry-based learning can inform the lecturer as well as the student was discussed by Jenkins *et al.* (2003), but they went a step further and argued that inquiry-based learning styles can enthuse the lecturer as much as the learner through re-engagement with the knowledge discovery process. Further benefits for the 'teacher' were identified by Wright (2005). In Wright's classification of lecturer types, a good (type III) lecturer is one who encourages debate, fosters discourse and facilitates 'real life' exploration and investigation. Therefore, it is argued, research-based learning enables lecturers to become better, more enthusiastic teachers and provides a more stimulating, student-oriented study mode that promotes deeper learning and greater understanding of the subject.

The discipline of physical geography has a knowledge base that is strongly driven by scientific investigation in the field (e.g. Rogers *et al.*, 1992; Kent *et al.*, 1997; Stodart & Adams, 2004). However, the dissemination of knowledge regarding physical processes and landscapes is often through the medium of tutor-led classroom-based lectures and practical laboratory classes. One exception to this rule is when fieldwork is incorporated into degree programmes. Fieldwork has long been regarded as an intrinsic element of learning and teaching in geography (e.g. Kent *et al.*, 1997; Robson, 2002; Stoddart & Adams, 2004; Panelli & Welch, 2005) and continues to feature in most undergraduate degree programmes despite the changing nature of the subject and constraints on time and resources (e.g. Gold & Haigh, 1992; Haigh & Gold, 1993; Jenkins, 1994; Clark, 1996; Higgitt, 1996a; Warburton *et al.*, 1997). Although fieldwork is regarded as the primary means for students to engage directly in research within Geography, Earth Science and related disciplines, published education research has tended to focus upon fieldwork as a means of developing generic field-based skills for gathering data, developing teamwork skills and producing reports (Kent *et al.*, 1997; Hill & Woodland, 2002) rather than a means by which knowledge acquisition within a sub-discipline is fostered. Undergraduate students therefore rarely have the opportunity to engage with the full process of inquiry-based knowledge discovery and acquisition, from the formulation of research aims and hypotheses to drawing meaningful conclusions, in a field research environment.

Research by Keene (1991) described the traditional Socratic approach to fieldwork and advocated that, instead of the rather passive 'guided tour', students use 'discovery methods' in small groups working on specific problems. Rather than being outside observers, students working in this 'discovery' fashion derive a sense of ownership and involvement in their own learning as well as contributing to a body of knowledge within the research environment. This type of fieldwork is essentially inquiry-based learning and teaching (Griffiths, 2004) and has the potential to be research-led, given the appropriate context. Keene's work has been endorsed and developed by many others (e.g. Haigh & Gold, 1993; Mossa, 1995; Higgitt, 1996b; Kent *et al.*, 1997). Unfortunately, the constraints on fieldwork (e.g. staff time, finances, the need to develop generic skills, competing elements of undergraduate learning and teaching programmes) seldom permit topic-specific, truly research-led learning in a field environment.

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Aims

It is widely regarded that research-informed teaching has enriched educational programmes in Universities (Healey *et al.*, 2003; Jenkins *et al.*, 2003; Hill *et al.*, 2004; Jenkins *et al.*, 2007), but for a number of identified reasons, there is relatively little publication of the experiences of inquiry-based learning (see Thomas, 2003). This paper reports on a research project funded by Staffordshire University as part of a university-wide research-informed learning and teaching initiative. The initiative seeks to develop a clearer research-informed learning and teaching orientation within undergraduate teaching programmes and to better understand the ways in which effective research-informed teaching can be employed to enhance student learning. This paper contributes to the growing literature on the experience of delivering research-informed teaching. In particular, the paper aims to evaluate the impact of a student-centred research experience, in an advanced course, upon both staff and students in response to a specifically designed research project. The aim of this project was to replace formal classroom-based teaching with field-based learning. Students would need to acquire knowledge of a range of phenomena within Quaternary science in order to achieve the specific research project objectives (as distinct from the pedagogic project objectives), and as a consequence achieve the same learning outcomes that apply to the module. We as teachers would be able to formally assess student knowledge acquisition through standard assessment techniques. By comparing the performance of this group of students with previous cohorts of students, and examining their module feedback as compared to previous students, we could evaluate certain aspects of the value of a field-based research-led mode of teaching.

The decision to use a student-centred methodology to deliver the module outcomes was based upon our experience with the Earthwatch-supported 'Icelandic Glaciers' project. The Icelandic Glaciers project supplies non-specialist volunteers to assist in field research. We observed the volunteers engaging with quite complex research issues year after year and this led us to believe that exposing students to a research problem would enable them to engage successfully in a co-learning environment and yet still achieve the learning outcomes for the glacial processes, landforms and landscapes (GPLL) module.

The approach described here could be repeated in other areas of physical geography where the model is tailored to specific topics. In this case, the model has specific aims within a Quaternary science context that will enable students to meet the general aims of developing student-centred research-informed teaching.

Therefore, the aims of this project were to enable students studying a glacial and Quaternary science module to achieve the learning outcomes previously associated with this specialized topic through a research-led learning agenda.

Background to the Teaching and Learning Experiment

The Existing Module

The module at the centre of this research is an Honours Level (third year undergraduate) module GPLL, an optional course within the Geography programme at Staffordshire University. The Geography programme consists of a mixture of compulsory and optional courses that ensure that all undergraduates have a good grounding in techniques of teamwork, inquiry and data analysis through a combination of skill-based laboratory classes at levels one and two, and compulsory fieldwork including week-long residential courses.

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Fieldwork is incorporated into skills laboratories, but the projects are of the 'known outcome' form (Mackenzie & Ruxton, 2007). Projects undertaken as part of a week-long field course at level two allow for greater freedom of topic selection and investigation and are seen as part of the training for the dissertation at level three, including the design and implementation of a research plan. The thirty credit dissertation is a significant (25 per cent) component of the final year assessment. This traditional research-led element of the geography programme is often considered in isolation by both staff and students: there is little opportunity to apply knowledge discovery skills within other learning contexts of the Geography programme, nor is there potential to engage in co-learning. A course such as GPLL, whilst dealing with research issues, does not traditionally provide opportunity for students to engage directly in knowledge-discovery activities. In this respect, it is no different to other courses in coastal geomorphology or urban geomorphology where the potential for original research to contribute to learning exists.

GPLL is traditionally delivered over a 12-week period (semester). It consists of a weekly programme of alternating fortnightly 1- and 2-h lectures. Early lectures highlight controversies that arise from recent glacial research within contemporary glacial environments (e.g. Iceland, Greenland and Antarctica). Foci include subglacial environments, glacial movement anomalies, ice sheet dynamics and the formation and drainage of ice-dammed lakes. Later in the module, contemporary understanding of glacial processes is related to the description and interpretation of Quaternary glacial landforms and landscapes within the UK. Evidence for Late Quaternary environmental change is examined on a regional basis, with particular emphasis on the Irish Sea Basin and the Scottish Highlands. At the very end of the module, a 4-day field course based in the Scottish Highlands provides the means by which major issues in the reconstruction of Late-Pleistocene Britain are explored (e.g. the extent and duration of ice sheets and glaciers, the influence of deglaciation on ice-dammed lake drainage and Quaternary landform development). The timing of the field course within the module is purely practical; the module runs in the second semester (starting after the Christmas vacation) and the field course therefore has been run in early May when the threat of significant snow-fall in the Scottish Highlands has abated. In addition, there is an abundance of daylight to exploit, which would not be the case if the module ran in semester one.

The field course has always been seen as an important element of the module. It provides an opportunity for discussion and criticism of 'cutting edge' research into geomorphological phenomena, whilst actually being surrounded by landscape evidence. Sites visited during the course include such classic locations as Loch Lomond, Glen Roy and the Parallel roads of Lochaber, Glen Moriston and Coire D'ho, and the under-reported Glen Etive. In effect, the field course is a field-based workshop, run over 4 days at the end of the course, where students can put their knowledge to test in a real world context. Interactive discussion of published accounts of the visited sites forms the basis of the learning experience. Many teachers of Quaternary science would recognize this model of a field course supporting the subject.

Delivery of the field course element of the module in the past has stimulated independent staff research activity; for example, on the basis of field observations, we developed a small research project and co-authored a paper on the deglaciation of Glen Spean (Russell *et al.*, 2003). It is this direct linkage between teaching experience and research in conjunction with our experience on the Icelandic Glaciers research project that inspired a desire to incorporate research activity into the teaching and learning experiment

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discussed in this paper, and represents a small response to Jenkins' (2000) call for us to 'stand and deliver'.

Glen Etive is traditionally visited at the end of the field course because the valley exhibits a wide variety of landforms and environments within a relatively small area and can be used to illustrate a summary of theories and concepts considered over the module, with regard to the deglaciation of Britain. Repeated field course visits to the valley over a number of years have informed staff knowledge of the area and have directly led to the formulation of this learning and teaching experiment. However, the problem with using Glen Etive as an exemplar is that there is relatively little published material concerning the landforms of Glen Etive, or the Pleistocene history of the valley. Thus, the use of Glen Etive as an example of a landscape of deglaciation is, in traditional teaching terms, rather unsupported, in that there is no substantial body of literature to reinforce our discussion of the subject matter. Therefore, the production of an academic account of the valley and its landforms is an important aim of this project.

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The Experimental Module

The assessment for GPLL traditionally consists of an essay completed part-way through the module, drawing upon material delivered in lectures, and a report based upon the field class and submitted shortly after it. The learning outcomes for the module are that students should, on completion of the module:

1. have knowledge about, and the ability to understand recent research issues and controversies associated with the science of both current and past glaciated environments;
2. be able to critically review scientific publications, synthesize material and demonstrate an in-depth appreciation of the processes at work in such environments;
3. demonstrate an appreciation of geomorphological and environmental change during the Loch Lomond Stadial (specifically in relation to the Scottish Highlands) and
4. demonstrate an advanced ability to express and communicate knowledge clearly.

A decision was made by the teaching team to deliver the experimental module to these same learning outcomes, but to re-organize the module to place student-centred, field-based inquiry at its heart. We devised the learning and teaching experiment to deliver the same learning outcomes as we have used before, and to assess the module through exactly the same types of assessment (an essay and a fieldwork-based report). The decision to retain the same learning outcomes acts as a control as it enables comparison with previous cohorts who have followed the more traditional model. Students were aware of the experimental nature of the module prior to signing up for the course, and were willing participants in the project.

A reduced number of lectures on glacial geomorphology and Quaternary environmental change were delivered, carefully targeted to frame the nature of the proposed field investigations. The students also participated in workshops intended to underpin the understanding of the glacial geomorphology and Pleistocene setting of Glen Etive and to facilitate the sharing and discussion of field observations between students and staff. The students were divided into research teams, following the small research group approach

advocated by Keene (1991). The field element was organized such that each team was allocated an area of Glen Etive in which the problem they were set was to investigate, describe and account for observed Pleistocene phenomena. The students were given the goal of producing a field guide to the 'Classic Landforms of Deglaciation' in Glen Etive, and directed to consider field guides published by the Quaternary Research Association and the Geographical Association as exemplars of desired output. In order to facilitate student learning, specific resources were required. Project funding was used to purchase 1:10 000 scale topographic maps and geological maps of the area, digitized 3D maps and most importantly, aerial photographs. The project funding also covered travel, accommodation and subsistence costs. Classroom-based and independent research were supplemented by two field research trips, one in mid-February after 5 weeks of teaching and the second in late April at the end of the module. These field sessions were designed to enable students to conduct fieldwork in their research teams in order to construct field guides to their section of Glen Etive.

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The Didactic Case for the Project

The traditional means of teaching GPLL involved a dependence upon a traditional lecture format. As lecturing staff, we had no reason to suspect that this form of teaching was failing; quite the reverse. Student feedback consistently rated this module as one of the most favourably received modules in the department. However, this does not mean that learning and teaching could not be experienced in a more satisfactory way. The traditional student learning process was essentially passive; students were given a series of lectures and a breadth of material that they were encouraged to research. The assessment process (answering an essay title from a given list) allowed student choice in their depth of learning, but there was a strong risk that learning would be superficial, in that this type of independent learning can be strongly tied to the assessment task. Thus, the development of deep learning across a significant breadth of the material may not have been taking place.

The Glen Etive project puts the need for learning into the hands of the students. Each research team was required to produce an element of the field guide. In order to do this, they had to obtain knowledge of investigative techniques necessary for the exploration of phenomena in the field, along with theoretical and contextual understanding necessary for valid interpretation. We had strong reason to believe that the students would be selective over their research, but that their selectiveness would be driven by a research need, not the need to answer an essay question. Thus, we reasoned that learning would be self-motivated; the lectures and workshops had guided learning directions, but the material would be sought by the students themselves. We predicted that students would derive a greater sense of ownership of learning, driven by the processes involved in the research, and that this sense of ownership would encourage deeper learning (e.g. Keene, 1991; Healey, 2005; Le Heron *et al.*, 2006).

Undertaking the Glen Etive Project

The student research teams were allocated early in the module and the teams began their independent work by researching background information relevant to their section of Glen Etive, using maps, aerial photographs and literature. Throughout this process, staff acted

as facilitators and sounding boards for discussion. The first field session, of 4 day's duration held in mid-February, began by introducing students to Glen Etive and its immediate surroundings, providing a contextual setting for the research. This prompted students to conduct reconnaissance of their allocated field area and begin their team-based field research, based on their preparatory work undertaken prior to the field session. On returning from the first field excursion, students had 7 teaching weeks (and 2 weeks of Easter vacation time) in which to conduct further research based on issues raised by their initial fieldwork. We adopted this two-phased fieldwork approach on the basis of our experience of the frequently iterative and developmental nature of field research; initial exploration frequently generates further questions and problems, which require recourse to literature and team discussion before the second phase of field research can be refined.

Following the first field session, a composite map of the entire valley was created, printed out as a large A0 sheet, and encapsulated in film. Students were encouraged to annotate the map and pin images onto it in order to create an *aide-memoire* for later study, and to stimulate thoughts. This process also facilitated discussion and the sharing of knowledge between (as well as within) individual research teams. In using this 'tasking board' approach (see Figure 1(a)), students moved from being passive recipients of selected knowledge, to active investigators who were setting their own research agenda.

The second phase of field research of 5 day's duration was held in late April. During this field visit, the research teams conducted their final field data collection (see Figure 1(b),(c)), the objectives for which were refined between trips. As part of this visit, the whole group also visited some further sites (for example, Glen Roy and Coire D'ho) to enable students to both use and augment their knowledge of landforms and landscapes of deglaciation acquired as part of the Glen Etive project experience. On returning from the second field research trip, students had 3 weeks to pursue final analysis and synthesize their materials before submitting individual field guides based on the research that they carried out for their allocated section of Glen Etive.

The ability to repeat the field experience and reflect upon the learning outcomes of the first field visit provided the distinction between the research experience facilitated through this module and the structured research experience encountered through more formal field investigation conducted as part of levels one and two fieldwork. In addition, the occasion to interact with staff as researchers provided a unique learning opportunity for the undergraduates. This opportunity is not experienced in short-term project work typified by traditional fieldwork activity, nor is co-learning a part of the dissertation experience.

Project Evaluation

The success of the project was assessed in a number of ways. Two critical tests of success were the student evaluation of the module, and their performance within the module. Further important measures of the effectiveness of the project were from the reaction of the teaching staff to the ways in which students responded to the tasks set during the course of the module. Although subjective, the observations made by the teaching staff in the light of their experience of teaching the module are relevant.

The students also had the opportunity to evaluate the project itself, and were invited to react to the experience of the module through participation in feedback questionnaires and to give free, unstructured criticism of the module. There were two questionnaire surveys. The first was a standard Staffordshire University end-of-module feedback form.

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Figure 1. Images of the students at work; (a) students constructing the 'tasking board' during a workshop following the first field visit. (b,c) Staff (T.H., partially obscured) and students investigating a section through a kame

This questionnaire contains 11 questions that allow the students to evaluate the quality and effectiveness of the module by means of a series of statements to which responses are obtained on a five-point scale from 'strongly disagree' (nominal value 1) to 'strongly agree' (nominal value 5) (see Figure 2). There is also an opportunity to provide open feedback through a 'comments' section of the feedback form. Analysis of these data enabled comparison with the experiences of students studying the module in previous years.

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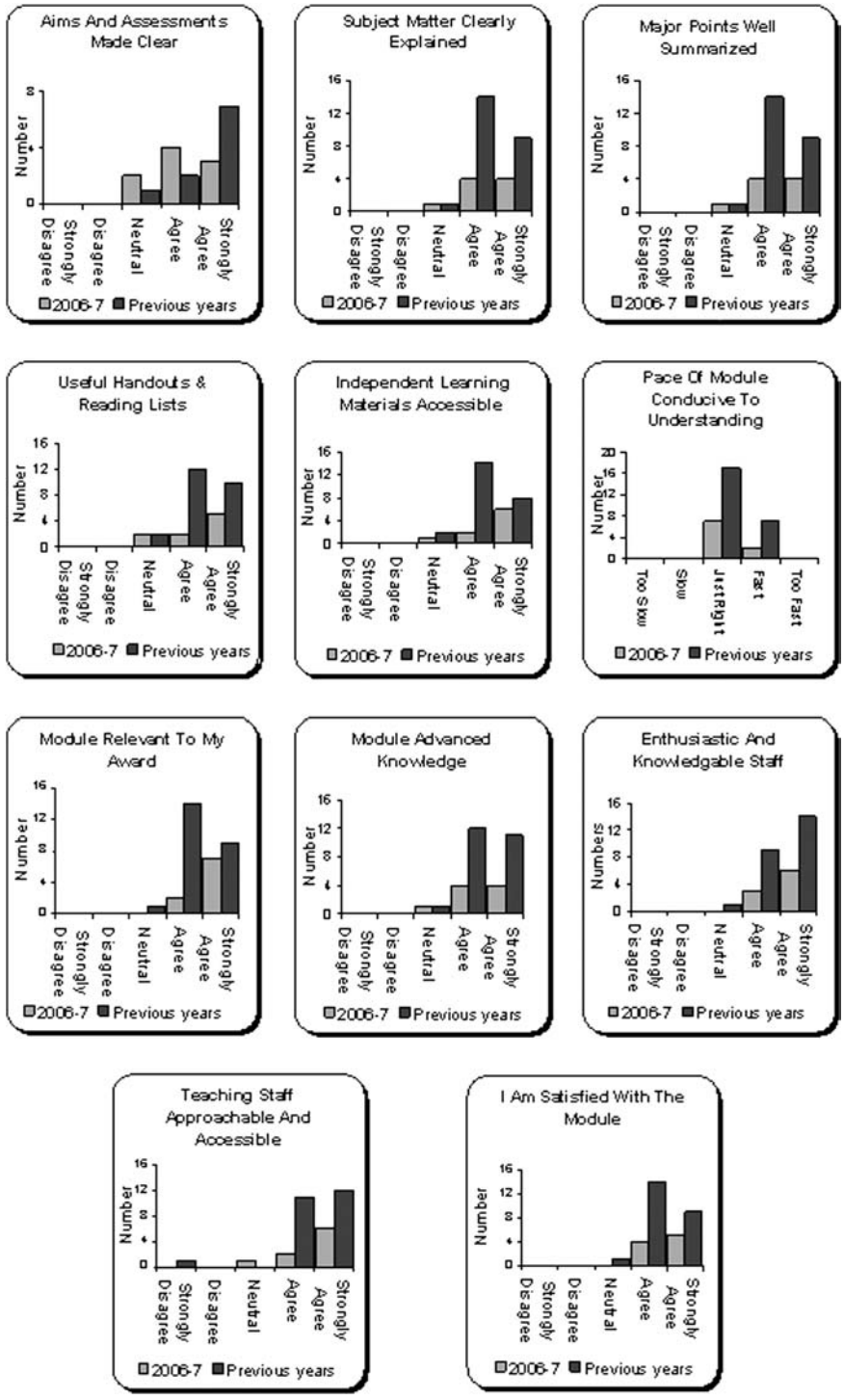

Figure 2. Student responses to the standard module feedback questionnaire

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The second questionnaire was specifically formulated to elicit feedback regarding the delivery of the experimental module. The questionnaire was structured into three sections: section 1 concerned the experience of the teaching and learning process in the module; section 2 invited an evaluation of both the personal and group learning experience during the module and section 3 was an overall evaluation of experience of the module. Each section contained structured semantic differential questions (on the same scale as before), and open questions with appropriate space for responses. Both this questionnaire and the module feedback forms are reproduced in the appendix.

At the end of the module, each student was required to submit a report on the particular aspect of the project that they were engaged in. The report had two facets: the first was the scientific description and assessment of their section of Glen Etive; i.e. the 'field guide'. The second component was an assessment of the pedagogic value of the project. The latter comprised both their reaction to the project and their evaluation of the value of their project to potential visitors to the field site.

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Results

The results presented in this section consist of (i) the formal assessment of students studying the module; (ii) an analysis of student responses to the standard departmental module evaluation form and (iii) a project-specific questionnaire. In addition, observations of undergraduate response to the tasks set are presented.

The small number of students on the module (nine) this year and in previous years (typically 10–15) means that trends and relationships identified through statistical analysis are weak. On a crude measure of mean module mark over time, student performance on the module is slightly improved when compared to the previous 2 years (the only 2 years with which direct comparison is possible). A mean mark of 60 per cent for the module compares favourably with mean module marks of 57 per cent for the previous 2 years (see Table 1).

The data presented in the frequency charts in Figure 2 show the response to the experimental module run in 2006–2007 as compared to responses aggregated over the previous 2 years. The 11-question standard departmental module evaluation undertaken by students demonstrates a positive reaction to the module. On the five-point scale, there are no mean scores below a threshold of 4.0 (agree with the statement, see Figure 2). The response to all questions demonstrates either a continued or an improved response as compared to those of previous years, with the modal response being either agree or strongly agree to all categories. A more rigorous analysis of results (to highlight trends, for example) is not appropriate because the run of comparable data only exists for 3 years in total, and the small number of students militates against an analysis of relative changes.

The structured responses are reinforced through unstructured feedback on the questionnaire. Students participating in the experimental module found the subject matter

Table 1. Mean module marks for the three most recent years

Year	Mean mark (%)	Standard deviation
2006–2007	60	7
2005–2006	57	10
2004–2005	57	9

interesting and they particularly enjoyed the field elements. In terms of the standard module feedback, the most frequent comments concern the field trip element; the field trips were 'excellent' or 'best ever' (all the students attended compulsory UK-based residential field courses in their first and second years and the majority participated in an optional foreign-based field course in their third year). This type of comment is repeated year on year. Other elements that students also comment favourably upon are the lecturing staff, the classroom sessions and the assessment mode; again these are perennial comments. During 2006–2007 (the experimental module year), comments suggesting improvement of the module were few and regarded improving orientation to the field site. In previous years, the major criticism has concerned the short length of the field course and its timing late in the module.

A second project-specific questionnaire produced a wider variety of responses (see Figure 3). The first question asked if the "module had encouraged me to achieve a deeper level of understanding of subject matter compared to other level three modules". A modal 'agree' response masks a more normally distributed range of responses compared to responses in Figure 2. This is comparable to the response to the third statement "in comparison to other level three modules, learning the subject matter for this module was more difficult" where a similar modal 'agree' response was produced by more normally spread data.

When asked to compare GPLL to other level three modules, it was agreed that the experimental module had enabled students to gain greater subject knowledge, and the data

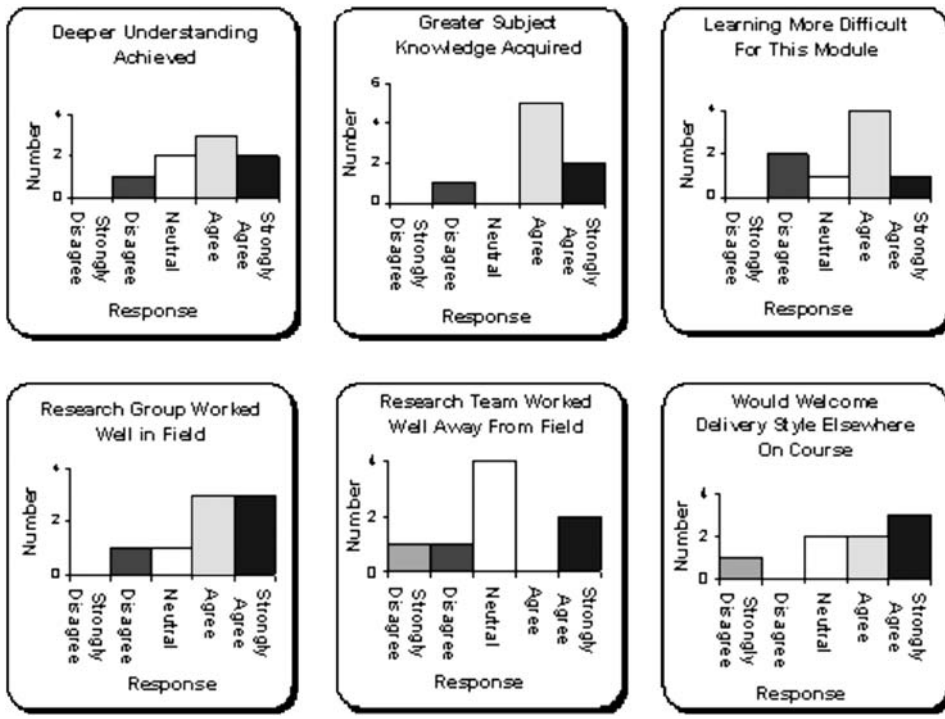

Figure 3. Responses to structured questions on project-specific questionnaire

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were heavily skewed to the positive. One non-scale question was asked, and this was to identify the place where most learning took place. Four respondents identified 'the field', three 'independent study' and two replied 'the classroom'. In the free response section of the project-specific questionnaire, students identified the field experience as being vital, because it "clarified understanding" and "it was excellent to see landforms in the 'flesh'". The team experience in the field was identified as making a positive contribution to learning because "we all took part in identifying landforms and put together our ideas to come up with a conclusion as to how they might have formed" and "the team had a pre-planned schedule of tasks which were completed on time and efficiently". By contrast, classroom-based team-work suffered from lack of group cohesion, typical comments being "data was shared but often jobs and information collecting was given to one person . . . that often left the other members of the team without research that they understood which was not good team work"; "not much was done as a team when the field course was over" and "apart from the sharing of field notes much of the research was conducted independently." These comments are reflected by the structured question responses in Figure 3.

In response to the statement "I would have welcomed this style of module delivery elsewhere on my course", the students responded very positively, 'strongly agree' being the largest response, but one person did 'strongly disagree'. When asked to provide free positive and negative criticism of the module, the work in the field was identified by all respondents as a beneficial experience. A typical comment would be "Because we haven't done anything similar to this in our 3 years at university it was a welcome change. It also made me think more about glacial features so that was another good thing". The words 'informative' and 'independent' occur in a third of all responses whilst sentiments reflecting independent learning are widely expressed. A typical example is: "the fact that we had to carry out our own projects made us think a little more [rather] than being 'spoon fed'." Interestingly though, when asked for comments on how to improve the module, all respondents wanted to be taught more, requesting more lectures either before, during and/or after the field courses! The only other frequent improvement-related comment related to the timing of either the work, or the field courses, or both, particularly in relation to other modules on their programme.

Discussion

The Undergraduate Perspective

One of the stated aims of the project was to achieve the module learning outcomes associated with this specialized topic through a research-led learning agenda. On a simple level, in terms of student performance, one can argue that the aim has been achieved. Students have demonstrated a performance comparable to that of previous cohorts. A higher mean module mark of 60 per cent with a more narrow standard deviation as compared to that of previous years is a pleasing outcome, but the weakness of the database in statistical terms means that it would be unwise to make any inferences concerning pedagogy based upon the data. As a teaching team, we are relieved that the module did not produce a poorer student performance as compared to those of previous years.

There are wider questions concerning learning style. The questionnaire survey indicates that the students themselves believed that they had acquired a greater subject knowledge,

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and at a deeper level as compared to other modules on their awards, confirming observations made by Bradbeer (1996) and Panelli and Welch (2005). This perception of deeper learning is supported by student performance on the module. Staff feedback comments on the assignments (including comments made by an external examiner) confirm that deeper learning and understanding was achieved by the cohort. Similarly, the 'field guide' produced by the students showed evidence of wider reading to facilitate explanation; where weaker performance was identified, which related it to poor structure or a failure to make linkage with a wider context beyond the immediate study.

The students' own evaluation of the experience reveals a diverse response. It needs to be recognized that the module was run as an experiment and as such was outside the normal experience and expectations of undergraduates taking a standard (i.e. classroom based) module. The questionnaire revealed that the students wanted more face-to-face teaching: this in part reflects their likes/dislikes, ability, the culture and expectation of what they perceive to be a 'normal' learning environment and may also relate to the way that they are being taught on other modules and their previous experiences of teaching generally. All respondents (bar one) would have welcomed the same style of delivery elsewhere on the geography course suggesting a clear desire for student-centred, research-led learning as part of a diet of different types of learning experience. Students clearly engaged with the material at a deeper level, as supported by some of the feedback comments (e.g. 'enjoying not being spoon-fed') as argued by Keene (1991) and Healey (2005).

Regarding the field experience and the group work associated with the fieldwork, the students perceived that the work seemed to be effective and there is evidence from their comments that they felt part of the 'discovery process'. Independent work in teams outside of the field seemed not to work as well, thus the full development of transferable skills is questionable. This reflects similar outcomes observed by Spronken-Smith (2005).

Staff Reflection on Student Experience

The reflections of the teaching staff reflect logistical and administrative issues related to duties elsewhere within the department, staff reaction to the teaching exercise and staff reaction regarding the relationship between teaching and the research.

On a rather mundane level, staff came across difficulties relating to duties elsewhere in the department, both administrative and teaching. Fieldwork needs careful thought and preparation, and in this case, an enormous amount of luck: the weather in February 2007 was exceptionally mild and an effective week of fieldwork was completed. As natural scientists working in the field, we can be hampered by climatic conditions. If we had come across severe weather, we may have encountered significant problems in delivering the teaching programme. Even as it was, the time spent 'in the field' (and preparing for the field visits) inevitably conflicted with teaching elsewhere (either our own, or clashes with other modules whose students we had 'removed' from the university) and with other administrative duties.

Consideration of practical difficulties has wider implications. For us, the greatest gamble was that there would be no lying snow, hampering appreciation of geomorphology. If the model were followed for other courses, there may well be climatic issues that need to be addressed. In our experience as field researchers, climatic factors cannot be ruled out; the ability to adapt to changing environmental conditions is a key skill of the researcher who has a limited window of opportunity to conduct research. Where

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environmental factors may prove more crucial to a project of this kind is with regard to the size of the research group. Adverse weather conditions may dictate that alternative opportunities for data collection are utilized. If the size of the undergraduate group is large, then the room for manoeuvre regarding alternative activities will decline. Although it will vary from project to project, it is inevitable that there is an effective limit to the maximum size of a group that is taught in the way described here, in the same way that there is a practical limit, for example, to the size of an expedition party engaged in research.

More positively as members of staff, the experience of delivering the module was very rewarding. Fieldwork has been described as intrinsic to being a geographer (Haigh & Gold, 1993) and vital in teaching geography (Kent *et al.*, 1997). Casual observation of student learning in the field and in the classroom demonstrated high levels of student enthusiasm for the learning process; field sessions were followed by intense evening follow-up work that was directed solely by the students themselves, staff acted merely as facilitators. Of further benefit was the opportunity to engage in direct field research in conjunction with the students: the 'co-learning experience' (Le Heron *et al.*, 2006). We were free to undertake our own field exploration and feed our field findings directly into the undergraduate work, and *vice versa*; the experience proved a very efficient means of undertaking field research. In practical terms, the staff and students were engaged in a simultaneous learning process. As a consequence, a field guide to Glen Etive is in preparation; the guide could not have been produced without the teaching and thus the nexus between teaching and research is most positively demonstrated.

Conclusions

This project aimed to evaluate the experiences of staff and students in response to the learning and teaching experiment; in addition, the project itself had a number of research aims. The project has shown that engaging students in the research process as part of a teaching strategy can be effective on a number of levels. Firstly, students value the experience; secondly, it has been shown that students can perform equally well as compared to those in traditional classroom-based learning and thirdly, students develop a deeper learning style and take control of their own learning experience.

Although the student experience was generally positive, the idea that all teaching be delivered through a research-led framework was not unanimously supported; there was support for research-led teaching to be a component of the undergraduate diet. The challenging, independent nature of the work may not be suited to all learners; this may in part reflect student expectation and the nature of their previous learning experiences. From a staff perspective, the style of teaching is stimulating and encourages staff to engage with educational issues as learners as well as practitioners, and has enabled the teaching staff to generate their own data for research purposes (Harris and Tweed, in preparation).

If this model of research-informed teaching were to be repeated, or attempted by other institutions, it needs to be recognized that a field-based, inquiry-led style of learning is expensive in terms of both financial and staff resources. Staff based in the field are not available to other students for educational consultation, whereas the money spent on one module in terms of accommodation, sustenance, etc. is not available to all geography modules. For us at Staffordshire University, the fieldwork and the project were only possible due to the funding for a research-informed teaching research project. The shortage of funds for undergraduate field research is a perennial issue for many

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institutions. On the positive side, it can be seen that this model of staff–student learning and research in locations that have been under-studied could represent a useful means of allocating scarce resources to produce desirable outcomes in terms of both undergraduate learning and research publications.

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Appendix 1: Project-Specific Questionnaire

Glacial Processes, Landforms and Landscapes 2007

Glen Etive Project—Student Feedback

As you are aware, we altered some parts of the module this year to allow for the fact that we wanted to incorporate some student-centred field research and obtained a grant to enable this to occur.

We'd be grateful for your feedback in response to the questions below. The purpose of this feedback is so that we can help to gauge your experience of the module, specifically of the Glen Etive project element.

Please return this form to Fiona Tweed—in room S112 or by email. Many thanks for your time.

1. This module has been delivered in a different way to other level three modules

Strongly Disagree Disagree Neutral Agree Strongly Agree

2. This module has encouraged me to achieve a deeper level of understanding of the subject matter of other level three modules

Strongly Disagree Disagree Neutral Agree Strongly Agree

3. In comparison to other level three modules this module has enabled me to gain greater subject knowledge

Strongly Disagree Disagree Neutral Agree Strongly Agree

4. Where do you think that the bulk of your learning was achieved on this module? (Please circle as appropriate)

Field-based Classroom-based Independent study

Please explain:

_____

_____

_____

_____

5. In helping you to understand the processes and landforms contributing to the landscape of Glen Etive which of the following would be more useful:

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6. How well do you think your research team (group of 3) worked in the field? (Please circle as appropriate)

Very Well Quite Well Okay Not Well Disastrous

Please explain:

_____

_____

_____

_____

7. How well do you think your research team (group of 3) worked when not in the field? (Please circle as appropriate)

Very Well Quite Well Okay Not Well Disastrous

Please explain:

_____

_____

_____

_____

8. Please can you identify three things that you thought were good about the Glen Etive project element of the module:

_____

_____

_____

9. Please can you identify three things that you thought could be improved about the Glen Etive project element of the module:

_____

_____

_____

10. Please can you sum up the key things that you have learnt from your participation in the Glen Etive project.

_____

_____

_____

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