bioscience education

Descriptive Account

Research-based Residential Fieldwork Learning: Double Bonus?

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Abstract

In the current Higher Education climate, there is a pressing need to integrate research and teaching in the student learning experience. In order to create synergy between research and teaching activities, to the benefit of students and instructors, we provided students with the opportunity to participate in a high profile collaboration between two scientific institutions. We planned and developed an integrated module leading the student through all the steps necessary in a large-scale, collaborative research project. Student feedback resulting from the intervention showed impressive levels of improvement in general appreciation of the course. Students also suggested that they would have liked a longer module, despite the intensive workload they experienced. All areas explored (general knowledge, research-based evaluation criteria, group and individual work) showed improvements in student evaluation after the module. We conclude that a residential, integrated experience of scientific research, from initial data collection to presentation at a scientific conference, can produce significant positive, active learning experiences to the students. A double bonus comes from the benefits towards research, both by compilation of data and long-term collaboration opportunities.

Keywords: barcoding, ecology fieldwork, institutional collaboration, integrated fieldwork, positive feedback

Introduction

Residential learning communities of students (in Higher Education) can enhance levels of involvement, interaction and overall learning advantages (Pike, 1999). Residential fieldwork courses are a vital part of the Geography and Ecology curriculum, despite the reduction in these courses in recent years due to budget cuts across universities (Higgitt, 1996; Smith, 2004). Acquiring knowledge, developing technical skills, attitudes and transferable 'enterprise' skills can be developed during fieldwork (Clark, 1996), but in order to engage students in active learning, residential courses need to be carefully designed and integrated into the wider curriculum (Kent *et al*., 1997).

Integrated research projects where students work alongside academic staff in residential courses often encourage active learning (Chickering and Gamson, 1987). Equally, staff can profitably employ problem-based learning during fieldwork approaches to encourage active and deep learning (Bradbeer, 1996). However, fieldwork provision has traditionally suffered from lack of alignment with the overall aims of degree schemes, and calls to further integrate fieldwork within broader pedagogic strategies has been stressed (Scott *et al*., 2006). The lack of evidence on the effectiveness of fieldwork on learning has been highlighted in the past (Gold *et al*., 1991):

> *"This literature on fieldwork in geography… is largely about assumed benefits, descriptions of particular field courses and specific field techniques. What is missing is evidence on whether or not the effort and expenditure are effective"*

Research is thoroughly embedded with teaching in the Biosciences, but often not made explicit (Sears and Wood, 2005). Research-based teaching may be viewed as well suited to residential, project-based courses and be set within an engaging, active learning format as well as contributing to staff research development in what may be considered a climate of 'publish-or-perish" (Hattie and Marsh, 1996). In the words of Gibbs (2001):

> *"The teaching/research nexus was addressed only to a limited extent... Mechanisms through which this nexus might be exploited are not yet articulated. Strengthening the nexus is at present an aspiration rather than a plan."*

A great deal of literature is available about Research Informed Teaching and its value within Higher Education (e.g. Jenkins and Healey 2005). There are many potential advantages to combining research/scholarship and teaching, which can be seen as distinct areas of academic activity. They can also be synergistically combined particularly when skills of carrying out research projects are at the heart of the learning outcomes, and may be particularly well aligned with Biosciences curricula and also associated residential fieldwork. For example, by leading the student through the steps of a basic research project the student identifies interdisciplinary methodology, sets out a concrete research problem, carries out the actual project and shares the new discoveries with peers (Dotterer, 1992).

Nevertheless, there is still a need to both; 1) provide evidence on the effectiveness of residential fieldwork courses with regard to the students' attitudes; and, 2) explore methods to profitably combine a 'live' research project with active student learning, a synergy beneficial to both the lecturer and the student. Synergistic interactions are based on positive feedback loops which promote growth, where the emergent pattern is usually "better" than the sum of its parts (Corning, 1998). For example, a student, faced with a final undergraduate dissertation project may consider the research process as an individualistic enterprise where motivation is achieved only through an initial personal interest in the topic. This may be short sighted in approach and may initially lack clear objectives and targets due to a lack of experience (Luck 2008). The experience of a real research process can inform future research planning, learner motivation and confidence in designing and carrying out meaningful research.

The intervention explored in this manuscript was motivated by the need to transform the relationship between scholarship and teaching from one of compromise, to one of synergy. To achieve this, student-faculty collaborations were facilitated during residential fieldwork courses and the new module on *Plant Diversity* addressed the following learning outcomes:

1. To develop skills on plant identification and general ecological and evolutionary context.
2. To appreciate the research process through active learning.
3. To develop structure and motivation from data acquisition up to manuscript publication.
4. To develop team work capabilities and awareness of interdisciplinary communication.
5. To develop independent thinking and reflection on the process.

This article reports on the potential of fieldwork to provide both a meaningful introduction to research and to contribute to a wider research project.

Methods

The development of an integrated research-teaching residential field course can be a challenging task. The difficulties associated with the organisation and management of any residential field course are cumulative with those necessary to build up a large-scale research plan, given the number of students involved, and the possibilities associated with entangling different institutions in a long-term collaborative project. The overall intervention came through the efforts of a number of people associated to two main institutions: the Institute of Biological,

Environmental and Rural Sciences (IBERS) at Aberystwyth University, and the National Botanic Gardens of Wales (NBGW), plus some collaborations from individuals belonging to other Welsh organisations. The proposed intervention was part of the 3rd year B.Sc. (Hons) Biology *Plant Diversity Field Course* module, for the first time taking place at NBGW and setting the first experimental research-based and research-targeted teaching project in IBERS. The module took place during the summer at the end of their second year in the degree.

The overall goal of the research project was to establish Wales as the first-ever country to compile its full plant barcode dataset. Establishing barcodes for every single species requires laborious laboratory experiments. Even when, on the global stage, Wales is a poor country in the diversity of its flora, it is estimated to possess around 1200 plant species. This long-term project, currently still in progress, involved the students in the very first steps of the project. However, in order to allow the 11 students taking part in the course to understand and identify with the project, all stages of the project's research process were taught at a basic level during the 11 day residential course. These involved:

1. Collecting and identifying samples of each native plant species in Wales (Days 1 to 8). Students visited different places within the National Botanical Gardens of Wales, collecting specimens, with identification in the laboratory afterwards. An introduction to the habitats of the Gardens had been performed in advance by personnel from NBGW. Students were continuously supported by experts in Botany to assist with the hardest steps of the identification process. .
2. Herbarium preparation and validation and tissue extraction (Days 1 to 10). Students pressed and labeled plant samples, providing the first specimens of the NBGW herbarium. A small piece of tissue from each sample was taken and frozen for subsequent DNA extraction in stage 4.
3. Short lectures (30 min. approx.) took place each night in order to set the project within a wider ecological and evolutionary context. Some took the form of classical lectures, followed by questions and discussion while others established discussion groups from the beginning.
4. DNA extraction. From day 5 onwards, students extracted DNA from the frozen plant tissue samples, assisted by IBERS staff.
5. PCR (polymerase chain reaction) (Days 7–9.). Assisted by IBERS staff, students amplified DNA corresponding to candidate plant barcoding markers from the DNA prepared in stage 4.

Expert staff (from IBERS and elsewhere) took part in all parts of the process, facilitating interaction with and between students. We attempted to enhance the students' motivation by informing them that they would be coauthors in any published journal or conference output. The students' learning experience was assessed using a final Likert questionnaire comprising 12 questions grouped in two parts:

1. General appreciation and appropriateness of course duration. *Appreciation* was taken as a comparison between the course and their initial expectation, and scored in a 5 points range from 'much worse' to 'much better'. *Duration* was equally ranged from 'much shorter' to 'much longer' for each stage of the course. In both cases a value above and below 3 corresponded to 'better' and 'worst' respectively.
2. In a second set of questions the students self-evaluated their attitudes and feelings before and after the course (5 points from very low to very high) on the following aspects (accompanying acronyms used in Fig. 2):

a) GA: General knowledge acquired.
b) IPA: Capacity to plan ahead.
c) IT: Improvement in independent thinking.
d) WST: Capacity to work in small groups.
e) WWG: Capacity to work as a whole.
f) WTC: Ability to work under time constraints
g) RIA: Awareness of interdisciplinarity in the research process.
h) RI: Interest or curiosity for research.
i) RM: Motivation or incitement towards research based on the research dynamic process.
j) RA: Overall awareness of the inner workings of the research process.

Besides the first question, the rest of them can be grouped in three areas: *b–c* correspond to the individual development, *d–f* are classified as capacity to work in groups, and *g–j* as attitude towards research. Due to the small size of the group and the nature of the Likert scoring system in the questionnaire, medians and their corresponding inter-quartile ranges were used for interpretation of results.

Results

General appreciation and duration

Students provided very high scores for the general appreciation of the course, the lowest median value corresponding to 4 (better) for the Herbarium preparation stage (Fig. 1), and none of the answers ever showed minimum individual responses below 3 (unchanged).

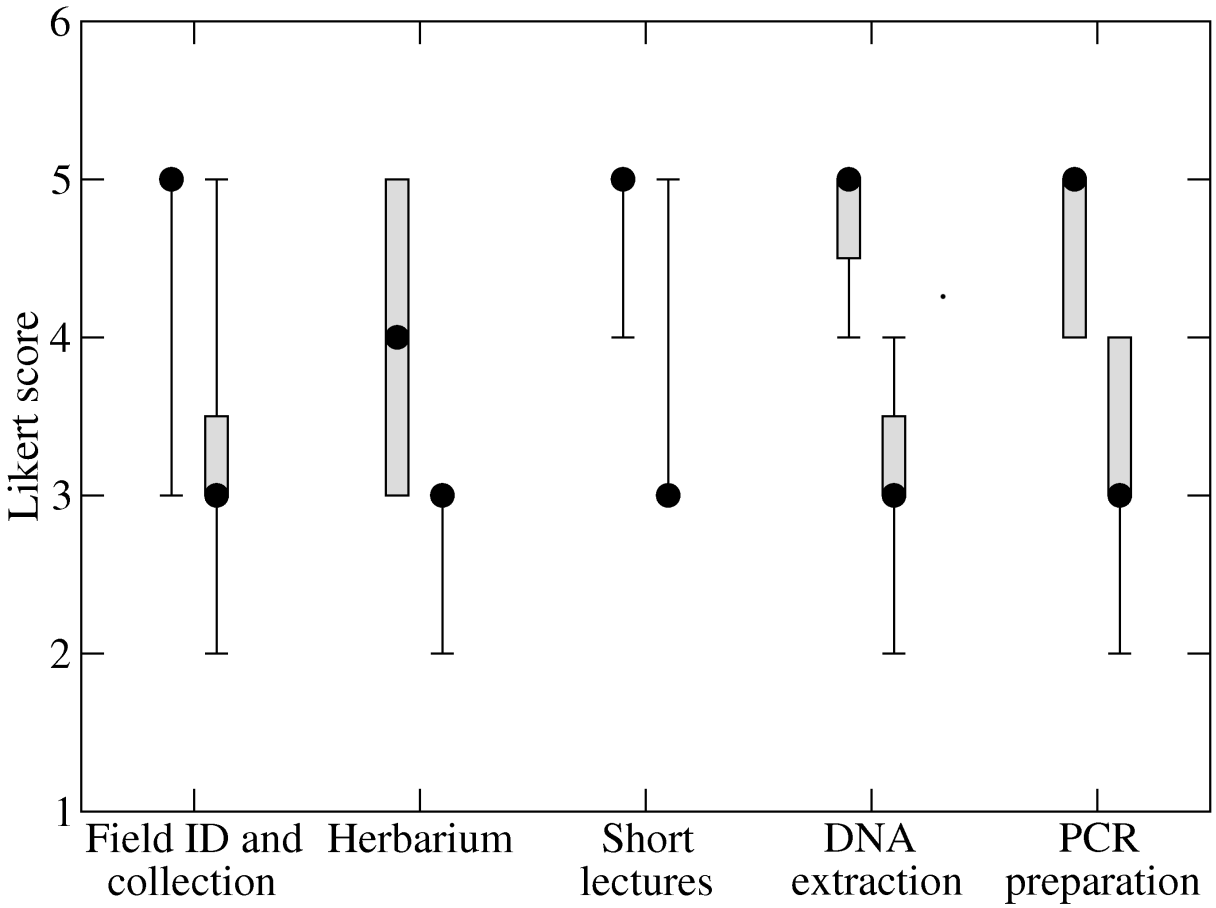

Fig. 1. *Likert score medians (circles), inter-quartile ranges (boxes) and extreme values (error bars) for each of the five stages of the intervention regarding general appreciation (left) and suggested duration (right) of 11 students.*

In terms of duration all the stages were suggested to have a proper duration (Likert median value = 3) although inter-quartile values tended to point towards a need for longer stages for lectures and laboratory exercises and shorter for the field and herbarium stages, the ones given in more traditional field identification courses. Overall, general appreciation scored between 'better' and 'much better' while duration had lower satisfaction scores(i.e. between unchanged and longer). The low inter-quartiles ranges in duration around the middle of the whole Likert scale suggest the students were happy (in general) with the timing of each stage.

Self-evaluation

Comparisons of the results between the appreciation of the learning process in each of the ten questions after the courses minus those before it are a measure of improvement (if larger than zero) or decline (if less than zero). In all questions there was improvement in their evaluation (Fig. 2). However there was an obvious trend by question groups. While general knowledge and overall awareness of the research process presented impressive improvements, those corresponding to working in groups, and especially improvements at the individual level were weaker.

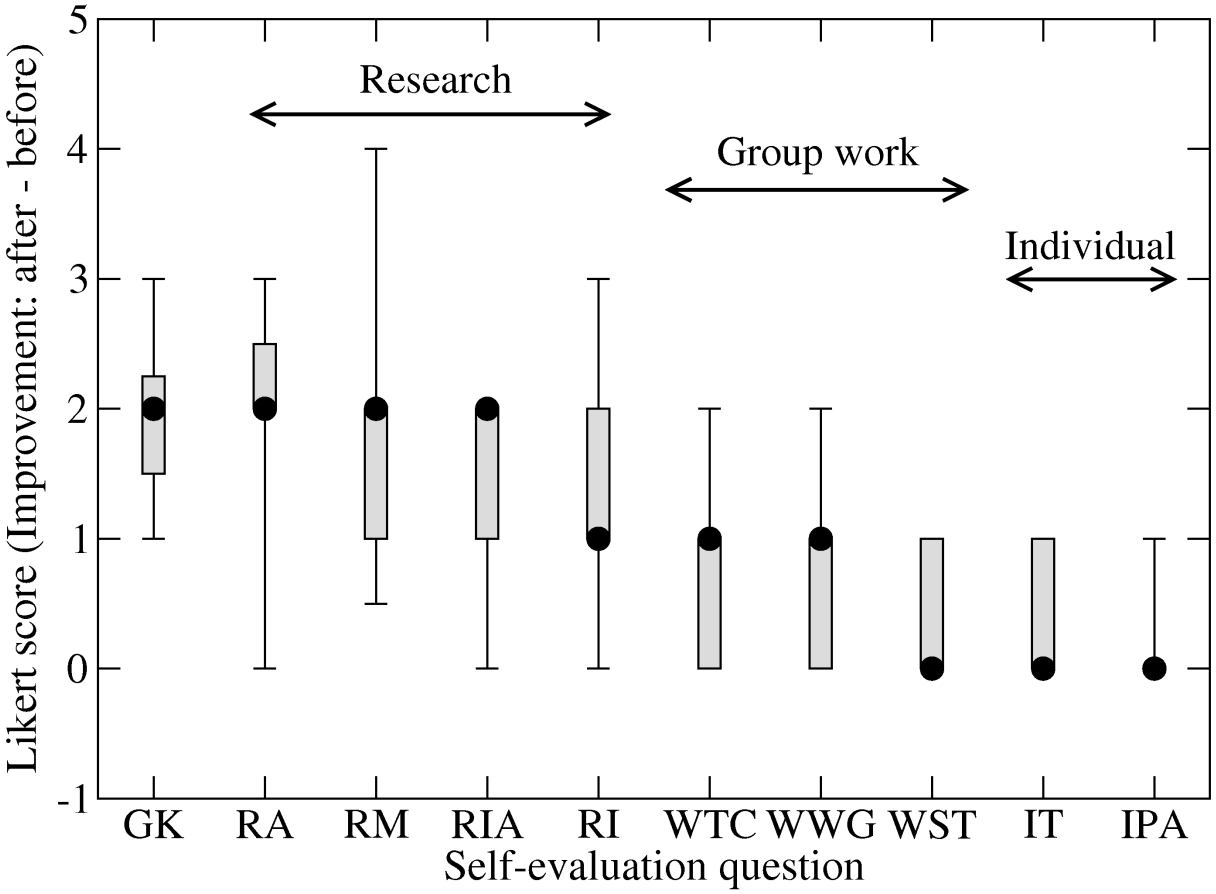

Fig. 2. *Improvement scores on self-evaluation of students in each of the ten questions formulated. Likert score medians (circles), inter-quartile ranges (boxes) and extreme values (error bars) for each of the five stages of the intervention are shown. Observe that there is a clear trend according to the groups of questions.*

Taking the average results for all ten questions, the median expectation per student before the course has a score of 3.1 with an inter-quartile range between 2.7 and 3.9. This median has gone up to 4.3 at the end of the course, with inter-quartiles between 4.1 and 4.7 (Fig. 3, left). Besides this improvement in the median and a lack of overlap between the inter-quartile ranges, the distribution of scores substantially changed. As opposed to the high variance and slight bimodality in student's expectations before the course, the distribution after the course

had a smaller variance and a positive skewness, pointing towards a more uniform opinion by everyone at the end of the course.

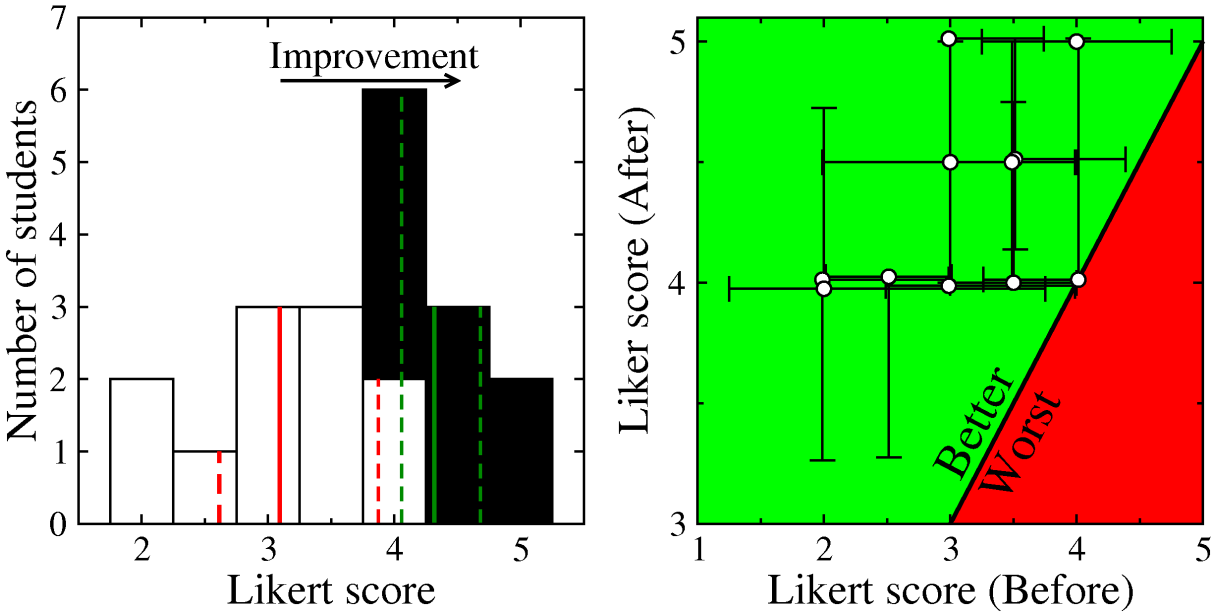

Fig. 3. *Overall improvement results. Left: Distribution of student's opinions before (white bars) and after the course (black bars). Median scores for the whole group before and after the course are depicted as red and green solid lines, and their corresponding inter-quartile ranges are shown as dashed lines. Right: Improvement as a function of the expectations per student. Medians (circles) and their inter-quartile ranges (error bars) over the ten questions in the self-evaluation part of the questionnaire are shown. For easier visualisation, some points are slightly displaced from their original coordinates (Likert score, natural numbers). Observe the differences between opinions before and after the course. Students with lower expectations recorded slight improvements in their opinion (the points farther away from the line separating better from worse), making the final distribution of opinions more homogeneous than the original expectations.*

How is this improvement manifested in each individual? While only one student showed no increase in median appreciation when all answers were pooled (although the skewness of the inter-quartile ranges still shows a slight improvement); (Fig 3, right), nine students showed median increases larger than unity in the Likert scale. The group of students with lower initial expectations (median initial score ≤ 3) projected a higher improvement than the group with higher expectations (median initial score > 3). The trend is clear, and shows that all students presented improvements. Yet, the small size of the whole group of students makes any further interpretation inappropriate.

Discussion

Integrated fieldwork, where students work in groups and undertake work in different stages (from fieldwork to laboratory analysis, and presentations in workshops) has been identified as a teaching tool that encourages enthusiasm, effective group interaction and empowerment in the decision-making process (Kneale, 1996). In this study, an integrated, long-term, research targeted approach was undertaken. As such, students did not take part in the decision-making process, a drawback probably reflected in the scarcely higher improvement they felt at the individual level. This is obvious from all the comments written at the end of the questionnaire by these students starting the third year of their degree:

> *"I think a full lecture at the beginning to introduce all parts would be beneficial so that we know what to expect in a few days time. This would make it easier to perform the initial stages with a view to later processing etc. I think this integration of field and lab work was much better"*

Staff reports on the course that were based on individual reflection and face-to-face conversations with the students, highlighted many of the benefits to students. The level of involvement of the staff seemed to be crucial to improve the student's ownership of the project. The external motivation for a targeted research output, recently presented by de Vere *et al.* (2009), underlines the importance of student motivation in this type of activity. Perceptions of teaching and research were embedded into each other, leading to perceived benefits. According to one student:

> *"Other than a little bit more organised, which under the circumstances wasn't possible in this case it was really well done. Doing a research-focused field course gives a reason to identifying and preparation which stops it feeling pointless. It also gives experience in a research environment (i.e. lab books) which is useful for CV's [sic]… Also shows you how research projects are done which could be useful if planning to be a researcher. It also gets your foot in the door in terms of who you meet. Really tiring, totally worth every penny ..."*

Supporting the findings of many previous studies (e.g. Haigh and Gold, 1993; Simm and David, 2002; Sears and Wood, 2005; Fuller *et al.*, 2006), the intervention encouraged students mostly in the areas of knowledge acquisition, research and group work. Feedback from participants of the current study did not necessarily suggest benefits in terms of individual development, as described by Tilling (2004) for secondary school fieldwork provision. The residential research-based intervention of the current study seemed to be ideal to complement much of the teaching already carried out in non-residential modules, which were more focused on individual instruction. The positive change in students' opinions, supports the provision of research-based field courses as alternatives to skills-based field courses.

Not reported in this study are the benefits to the research project itself. As a pilot study, it greatly profited from the workforce that 11 students could supply in the field. Most importantly, the course served as a platform to start a long-term research collaboration with the National Botanic Gardens of Wales and the National Museum of Wales, which is still in place today.

Some disadvantages of the approach were raised by the staff. First, a greater focus on individual decision-making in the research process is desirable (see Alsop and Ryan, 1996). An inclusive project preparation session(s) that considers project management, philosophy and other pertinent project-related issues could have been carried out several weeks before the course. Staff suggested that this may have enhanced the performance of the students and also the success of the pilot study. Students would have had the capacity to think in advance about the rationale behind the research approach and the hypotheses underpinning the study. They would also have had plenty of time to read the appropriate literature to develop a stronger background in the topic that would give them a basis for decision-making. This was clearly reflected in some representative student feedback after the course:

> *"More info beforehand (I know it was hard)"*

> *"It might have been helpful to talk about how to write a lab book on the first day as I didn't know what was expected from me. Would have enjoyed a longer time on the field course"*

> *"Maybe allow a background reading to the subject and identification prior to the field course. Lectures on lab book write up".*

Residential courses can be expensive forms of delivery in H.E. and can cost more than managers would be eager to approve. The number of expert staff involved, and other resources (equipment) called for a careful and systematic preparation to minimise the expenditure without compromising the excellent results that this intervention produced in student's attitudes. This approach has elicited questions about the most effective approaches to manage costs with learner and staff benefits. These are accompanied by larger, organisational challenges in terms of perceptions of fieldwork as a synergism between teaching and research. At the local

level several developments are being evaluated to enhance the current studies' approach: 1) an induction meeting where students will know the overall aim of the course and the basic structure of a research project; 2) a reflection time that will give the students the opportunity to autonomously input ideas and hypotheses (Adams 2009, Langan 2009) to be discussed either in the class or through some e-learning procedure (i.e., a blog or e-mail discussion list); 3) residential course with an induction class to establish the methodology (including a thorough explanation on how to fill laboratory books); and 4) a final reflective class where group (and potentially, face to face) feedback is carried out.

The benefits to students in a well managed, integrated, research-based fieldwork experience (in our opinion) easily compensate for any additional budget requirements. There are also the benefits to research coming from data compilation and analysis by a large group of people, but also from the potential to establish long-term collaborations between institutions. Hence, a double bonus comes from research-based field courses, benefits to students, and benefits to research. We acknowledge the need for evidence-based comparative research on the learning benefits of both, residential and non-residential approaches to research-based teaching and learning provision. Comparative and longitudinal studies to provide evidence of benefits of this type of approach for both learning and research are now required. Preferably at large/long term scales to capture demonstrable improvements to learning as a consequence of these experiences data providing further insights, into real benefits in student performance.

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