Evaluation of the Enquiry-Related Skills Developed by Final-Year Students Completing a Team Research Project in Biosciences

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Abstract

In recent years within the Faculty of Life Sciences (FLS) there has been a growing preference for final year project work that does not involve lab-based work. Whilst it is not clear what precisely is driving this change in student preferences, it is the reality that many FLS graduates are no longer taking up careers in which subject-specific knowledge and skills are critical (FLS, unpublished data). This case-study describes the development and piloting of the Life Sciences Enterprise Project (LSEP), a final-year 40-credit unit that runs over two semesters. This unit combining enterprise and life sciences employs an Enquiry-Based Learning (EBL) approach that aims both to deepen the students' subject specific knowledge and to enhance their employability.

In this unit an authentic scenario is created by setting each student team the challenge of developing a business plan for the commercialisation of knowledge and technology closely linked to the research interests of that team's FLS supervisor. The nature of the task provides the students with many opportunities for personal development which are identified and captured through reflective self-assessment. Though EBL is a not a new experience for these FLS students, the duration and complexity of the team-based project work undertaken in the second semester are quite different to anything that they will have done before. Therefore, the syllabus for this unit was structured so that the activities undertaken in semester one (S1) prepare and equip the students for the group-based EBL-project work in semester two (S2).

This case study describes the background to the project; the rationale behind the design of the unit; how the unit was delivered and assessed; and an evaluation of the skills the students developed during the course. We conclude with a discussion of some preliminary observations from which we have proposed some recommendations for delivery during the academic year 2007/8.

Background

The inspiration for the unit came from Dr. Richard Prince (FLS) after a presentation by Dr. Stefan Przyborski on a unit delivered at the University of Durham (Przyborski 2006) combining enterprise and life sciences. Following a successful application for CEEBL funding, Richard brought together a small team (Henery, Fostier and Speake) who were tasked with developing a 40-credit unit running over two semesters for delivery in September 2006. The unit draws upon two existing units devised and delivered by Manchester Science Enterprise Centre (MSEC), MSEC4001 (Entrepreneurial Commercialisation of Knowledge) and COMP40922 (Business Feasibility Study). When combined, these units require students, working as individuals, to identify a commercial opportunity and explore its feasibility. Then working as a team, they evaluate these opportunities and to develop a business plan for the one that they feel has the most promise. The LSEP syllabus was augmented with a series of tutorial activities focusing on personal development and team-working, and a review of the scientific literature underpinning the commercial opportunity. The LSEP unit was constructed into two phases, a preparatory phase delivered in S1 and the team-based project work undertaken in S2.

The unit was advertised to Year 2 students using the FLS intranet. Interested students completed an application form, including an explanation of their motivation for wanting to undertake the unit. This procedure was used to help select the final cohort which had been capped at 30 students; this was felt to be an optimum number for this type of delivery. The unit was successfully piloted with a full cohort of thirty students in the academic year, 2006/7.

Rationale

Prior to September 2006, projects open to final-year FLS students included traditional laboratory-based projects and a range of education and communication of science research projects. The latter class of projects were in the main undertaken by a small, but increasing, minority of students that did not wish to pursue a laboratory-based career. This is probably a reflection of the fact that in the past 40% of our FLS graduates progressed to a non-science career whilst others went into 'commercial bioscience' (FLS, unpublished data). A need was, therefore, identified for a new type of final-year project providing students with competencies necessary for the business world, i.e. transferable skills and commercial awareness. This was evidenced through a preliminary survey carried out by Kate Maull, CEEBL intern at the time, which revealed that 100 out of 450 students would be interested in a project combining biosciences and business.

Most employers, large or small, will look for self-reliant graduates who are independent and active learners. Our goal was therefore to identify and develop an approach to project work that would provide students with a real opportunity to practise and develop the skills desired by employers (Table 1). EBL is one such approach providing a range of key benefits as reviewed by Kahn and O'Rourke (2004). The combination of EBL in an enterprise context would provide the students with a scenario which was both authentic and fairly common, though by no means easy to successfully address. The nature of the task would provide students with many opportunities for personal development and reflective self-assessment.

- The ability to learn things quickly but informally: *able to learn by doing*

- A practical and common-sense nature: *good at finding workable solutions to problems*

- Flexible individuals: *all-rounders who can pick up a basic knowledge of subjects as required, e.g. finance, marketing*

- Work with minimal supervision

- Work well under pressure

- Results orientated

Table 1 Qualities valued by small to medium-sized employers (adapted from University of Kent 2005).

EBL is a not a new experience for FLS students, but the novelty of the feasibility study that each student has to complete in S1 and the duration and complexity of the team-based project work in S2, are quite different to anything that they will have done before. To ensure that students have the best chance to engage with the project and perform to their full potential, we structured the course in S1 to provide adequate and appropriate opportunities for students to develop the necessary knowledge base and the relevant skills (outlined in Table 2). A series of business workshops would help identify the type of knowledge required for the task: how technology is commercialised; the activities involved; and how commercial opportunities are evaluated. A series of tutorials would offer activities to help develop soft skills and reflective practice.

- Learning to manage their project and their resources

- Deciding the resources and information they require to complete the task

- Developing creative problem-solving skills

- Developing critical thinking and decision making skills

- Assigning roles according to personal (and team) strengths and weaknesses

- Finding ways to work effectively as a team

- Reviewing their own and their team's progress

- Identifying and reflecting upon the competencies they have acquired and how these may be further developed and applied to future tasks.

Table 2 Process skills required for effective project work (adapted from PBLE 2003).

Approach

30 students from degree programmes across FLS registered for this course and were divided into six teams of five students (mixed teams of male and females). Each team included students from different degree programmes to maximise the breadth of specialisms and perspectives available within each team.

In S1, each team was assigned an academic supervisor within FLS who chose the research 'theme' of the team, e.g. gene therapy, biostatistics, etc.. Within that theme, each member of the team was asked to consider a potential avenue that may lead to the development of a service, e.g. consultancy, technical; or a product, e.g. therapeutics, diagnostics, medical device, etc. Students could tailor their avenue to their degree programme and personal interest. This S1 individual research work was captured both through a literature review and a feasibility study, and summarised in January in a poster describing the individual student's commercial opportunity.

During the poster presentation, students received feedback from both LSEP tutors/supervisors and professionals/practitioners from the biotech sector. Each team

then had four full days to evaluate their five commercial opportunities and to select which one they wished to develop further in the form of a business plan during S2. The final activity of S1 was a team presentation of their selected opportunity and the rationale behind their selection to an audience comprising the other LSEP students and the LSEP tutors/supervisors.

This whole S1 process was supported by a series of lectures, workshops, tutorials (see Rationale), on-line material (WebCT and the Internet), individual research and independent learning activities (Figure 1).
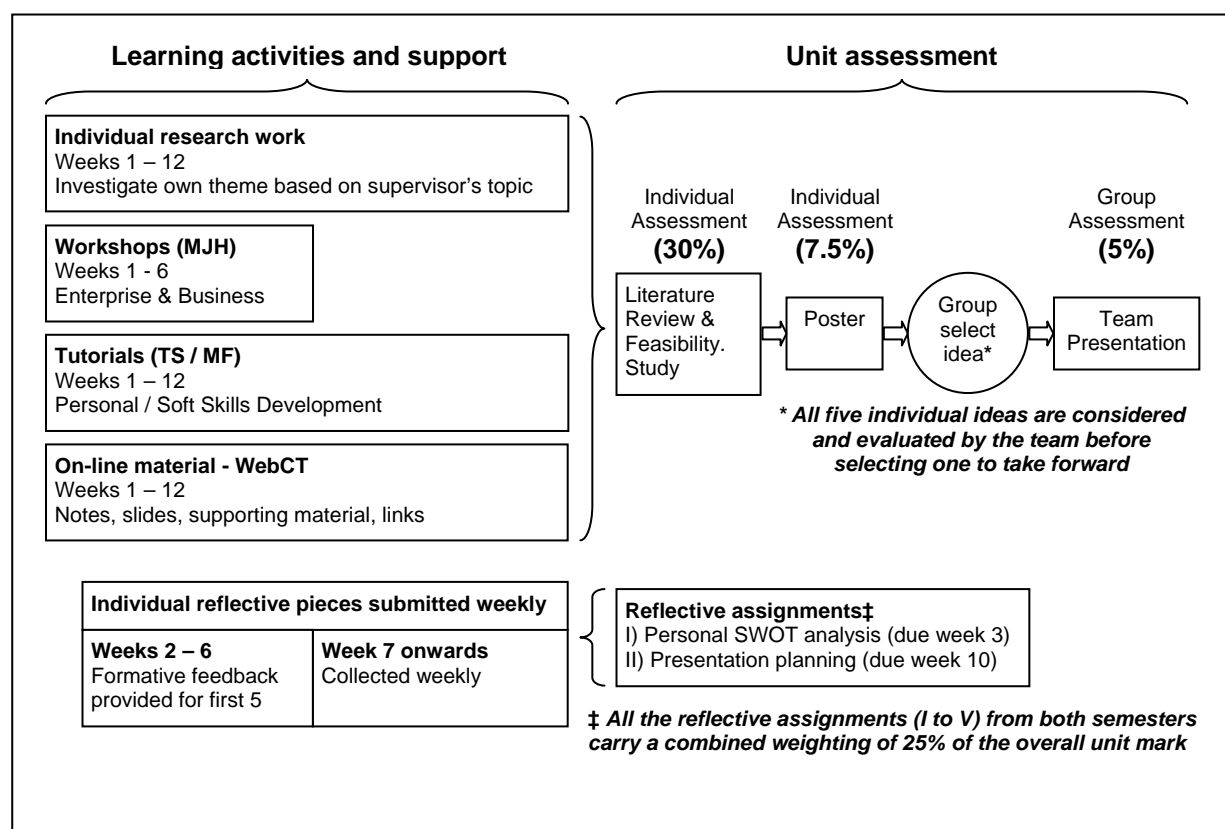

Figure 1 Preparatory phase (Semester One).

In S2, the teams had to develop a written business plan for their selected idea and pitch their business proposal to a panel of biotech and technology transfer professionals and practitioners in a format similar to the popular BBC series *Dragons' Den*. As in authentic situations, no formal taught input existed and teams were expected and encouraged to establish their own objectives and to draft the action plan that would enable them to meet those objectives. Knowledge was generated in an EBL fashion: each team member was responsible for undertaking a number of tasks and for feeding back their findings

to the rest of the team. Together the team evaluated and assimilated their findings and reflected upon whether they were still on course or whether they needed to modify their planned activities and/or objectives.

Figure 2 illustrates the various mechanisms by which project work was supported, ranging from weekly project meetings to assess progress and address any problems; personally arranged interviews in which the teams met up with real-life entrepreneurs; through to arbitration meetings to deal with serious team-working issues.

Finally, to capture and identify the individual learning and personal/team development throughout the unit, each student was required to submit a series of weekly reflective pieces, some weeks on set topics but most weeks on topics of their own choosing. Typically, the reflective pieces enabled students to describe and reflect upon their experiences; identify what had been learnt and how they might develop this further; and set goals and create action plans as appropriate. This would have immediate application enabling the students to plan and prepare for the range of different activities they would encounter as part of the unit.
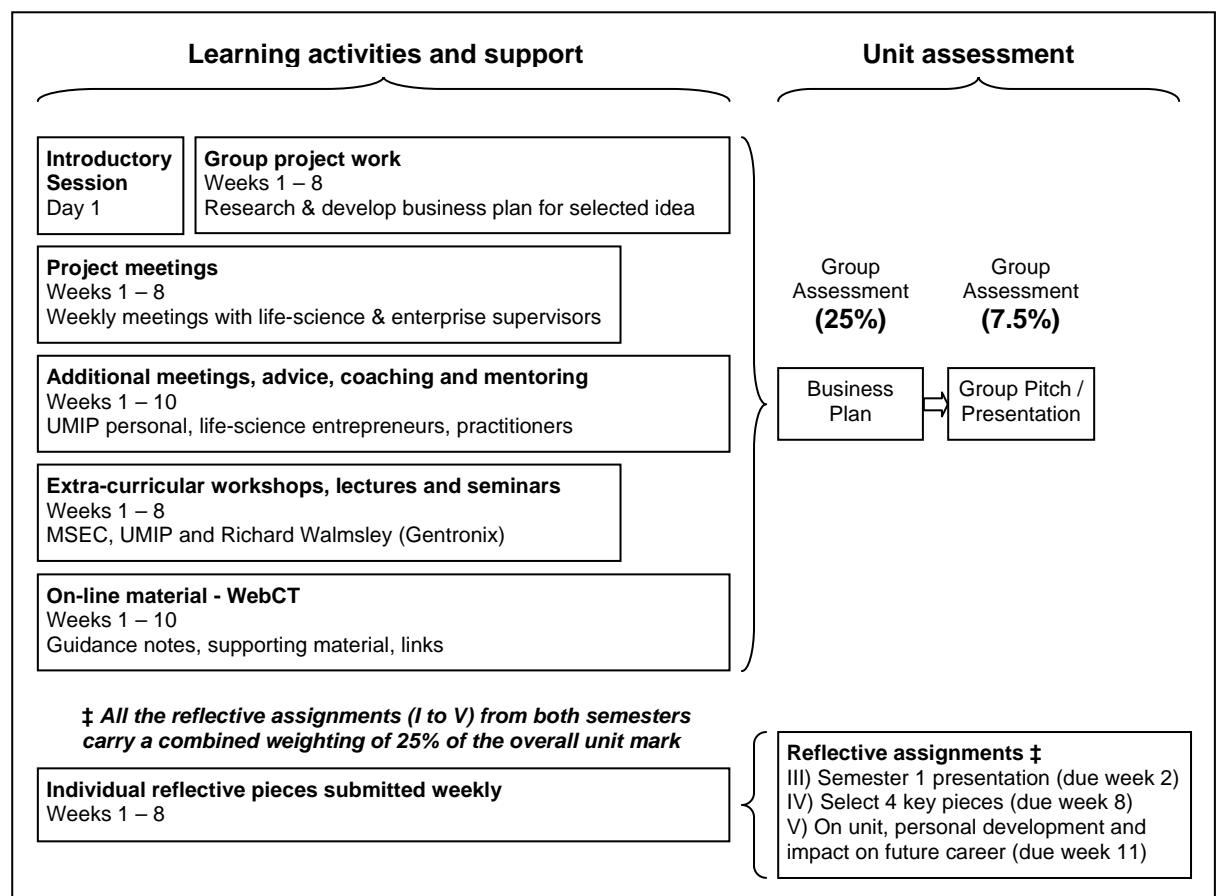

Figure 2 Team project phase (Semester 2).

Assessment

Students were assessed on 11 deliverables/activities whose weight varied from 5% to 30% of the final unit mark (see Figures 1 and 2). The individual/team mark split was 62.5 / 37.5% to ensure that this project remained on a par with the other types of FLS final-year projects which are all performed individually.

In developing a wide range of assessment activities, we drew upon personal experience, relevant literature and practitioner input as appropriate. We, therefore, felt fairly confident that each one of the assessment activities developed for this unit reflected as far as possible a realistic professional situation. Most activities were not new to the students, e.g. FLS students produce a poster in Year 1, a literature review in Year 2 and other group work tasks and oral presentations. The feasibility study, business pitch and the business plan were all new to the students, but these assessment activities have been employed numerous times by MSEC and so the work involved both for students and staff and how each activity would be assessed were fairly well understood. The reflective logs were perhaps the assessment activities that required the most thought as both the development team and the students had little or no experience of them. The reflective logs served a dual purpose: (i) they provided a key tool through which learning and individual development could be captured and recognised; and (ii) they served as means of generating evidence of a strong individual component to the unit which had been a specific concern of the FLS Education Board. Assessment activities based on the reflective logs were together weighted at 25% of the overall unit mark.

Evaluation

The focus of this case study was an evaluation of the enquiry-related skills developed by the students over the duration of the project. This evaluation was achieved in a number of ways:

- monitoring the teams' progress during weekly meetings;

- staff-based assessment as to the quality of the end products/deliverables of the EBL-driven projects;

- student feedback through a comprehensive end-of-unit questionnaire;

- indirectly from the students through several of their reflective pieces on EBL.

The questionnaire covered a range of areas including:

- the students' overall perception of the EBL experience;

- their perception of the skills developed within this unit;

- their experiences of team working;

- the usefulness of the workshops, tutorials, staff support and additional resources in preparing them for the activities in S2.

Enquiry-related skills developed or acquired during LSEP	Disagree	Neutral	Agree
Confidence	4%	21%	**76%**
Perseverance	12%	25%	**62%**
Using own initiative	0%	13%	**87%**
Creativity	4%	38%	**58%**
Data-mining (capacity to find information)	0%	29%	**71%**
Problem solving	0%	42%	**59%**
Time management	4%	42%	**54%**
Task management (planning)	0%	29%	**71%**
Flexibility	0%	**54%**	46%
Organisation	0%	21%	**79%**
Self awareness as a learner and team worker	4%	17%	**79%**
Capacity to reflect on past experience	21%	13%	**66%**
Capacity to reflect forward (preparation for tasks)	4%	33%	**63%**
Sense-making (being able to deal with incomplete and/or disparate information)	0%	46%	**54%**
Decision-making	4%	21%	**75%**
Networking skills (being able to identify useful contacts, make contact and get information from that person)	4%	29%	**67%**

Table 3 Summary of responses from students (*n* =21) asked 'has LSEP helped you develop or acquire the following skills?' The majority responses are highlighted in bold.

From Table 3 it can be seen that the majority of students felt that they had developed skills such as confidence, initiative, data-mining, task management, organisation, decision making and task planning. A smaller majority felt that they had developed other skills, such as perseverance, problem solving and networking, while only half felt that they had developed skills in creativity, time management (in practice) and flexibility.

These results were very encouraging and consistent with the staff opinion that to a large degree most students had undergone significant personal development in the desired skill sets.

The quantitative data captured in Table 3 indicates that the majority of students had been able to understand the ethos of EBL and so gaining many opportunities for personal development was supported by a number of the reflective pieces recorded by the students.

Typical of the comments focusing on the benefits of EBL were the following:

> *I now realise that the route taken to producing the final product is just as important as the final product itself AND that it can have a massive bearing on it.*
>
> *In LSEP we have never been spoon-fed a 'right' or 'wrong' way to tackle a particular task. Instead, we are encouraged to work through problems in whichever way we feel is best suited. By coming up with solutions, rather than following guidelines, I feel like I've learned more about how to, e.g. come up with an action plan or produce a poster, whether successful or not.*
>
> *At the beginning of the project I did find the concept of EBL quite difficult because I expected to be taught the elements of the project that required business knowledge. I still think that EBL is quite hard especially as I was not familiar with the business aspect of the project, but as the weeks have gone on, I think that my research techniques are becoming more productive … I realise that it can take a long time, but I am pleased that I am getting the hang of EBL, I think that this is a good skill to exercise because I am becoming a more efficient independent learner.*

Towards the end of the unit the majority of our students had not only got to grips with EBL but had begun to fully engage with it. Unfortunately, this was not true of all the students with a minority having not enjoyed using EBL methods. Their engagement was a fairly reluctant one—feeling that the structured part of S1 had done little to prepare

them for the activities of S2, e.g. researching and writing the business plan. Typical comments from these students included:

> *I learnt nothing!, You didn't teach me, I had to learn for myself!*

> *Should have been lecture-based, such as how to do a break-even analysis. I know we have to use EBL, and we did, as we worked out how to do a break- even analysis, etc. If MSEC did not run taster courses [part of our support programme], it would have been harder.*

While about half the students made good use of the support provided and saw its relevance, for the others, it was not obvious that they needed to transfer the skills acquired in tutorials or workshops through generic activities to their own project:

> *Would have liked to spend more time applying activities to project, i.e. applying creativity to the use of the technology.*

Conclusions and Further Development

On the positive side, all of our students carried out their project in an EBL fashion and developed to varying degrees a range of target skills (Table 3) as evaluated by student and staff feedback. Less satisfactory was the fact that only 60-70% of our students had fully engaged with the EBL process. Many of our students get used to a standard method of delivery and despite having had previous experience of EBL, find change something that they are unwilling or unable to embrace. It is possible that in many cases they had not really allowed themselves time to think through the issues in taking a unit running over two semesters predominantly based on EBL.

To address this issue we have adjusted the application form to ask students to reflect on occasions where they have used EBL, highlighting what the benefits were and how they think they could cope with an EBL course. As part of some limited changes to the delivery, we intend to spend the first tutorial session exploring as a class the skills associated with EBL and how they are transferred into practice, beginning with their first EBL deliverable, the literature review. The point of these changes is to set the right expectations from the outset and make sure that students are fully aware of what EBL entails. Last year many students, despite having been successful at small EBL tasks in S1, lacked confidence in their abilities to become independent learners, simply because they

did not recognise that they had already successfully undertaken EBL. These changes should hopefully help increase their confidence with EBL.

Many of the students also thought that our approach in S1 did not prepare them well for the team-based EBL project in S2. Whilst there is clearly room for improvement in the content of the structured part of the course, we have also realised that we simply need to clarify the intended learning outcomes of S1, and encourage students to constantly consider how skills/processes developed from generic workshop/tutorial activities, such as planning or creative problem solving, are relevant to their project specific activities. The University of Manchester promotes a whole range of relevant seminars and workshops and now that we have all the information regarding these, as well as continuing support of biotech and technology transfer practitioners and professionals who were involved with the pilot programme, we can fully integrate these additional support mechanisms into the curriculum.

Preparing and supporting students for EBL is not an easy process. It requires a delicate balance for the tutors, who cannot be too prescriptive, as they have to allow the students to think through the issues themselves, and can end up being perceived as being difficult, unhelpful or incompetent by never seeming to provide a straight answer to a student's question. One has to find the right amount of support to offer and the right timing. Failure to do so may give students the wrong perception of EBL and could disengage them. We have already seen in this pilot year that when students encountered problems with EBL, they were much too readily putting them at the feet of the staff and/or the unit itself. So we need to somehow hand ownership of these issues back to the students, allowing them to take fuller responsibility for their learning while continuing to support that learning.

In this respect, we need to carefully review the resources that we make available to the students. While it is necessary to 'pump prime' their activities, it is important not to provide them with everything that they could possibly need so removing the reason for directing and undertaking their own lines of enquiry. We therefore need to decide, now that we have more experience, what can be assumed as a starting point and what they would be expected to develop themselves during the course of the unit.

Though there are some other definite areas for improvement in addition to those discussed above, it is important not to lose sight of the overall aims of the unit which

are to offer a worthwhile alternative to the existing project choices that would at the same time enhance employability. Our next step is to follow the progress of our first cohort of students and begin to monitor and then assess the long-term career benefits of EBL in general and the Life Sciences Enterprise Project in particular.

Acknowledgements

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