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Title: Maximising the impact: using REF Case Studies to enhance first year undergraduates' appreciation of research integration in their degree.

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Title: Maximising the impact: using REF Case Studies to enhance first year undergraduates' appreciation of research integration in their degree.

Abstract

Integration of research into undergraduate degree programmes has been shown to have a beneficial effect on student learning, however integrating activities which help first year students to feel engage with research activity within their discipline has proved challenging. This study describes the use of Impact Case Studies created for the Research Excellence Framework (REF) assessment in the UK to develop a module for first year students allowing them to engage with research undertaken at their own institution which has achieved significant impact. Using a mixed methods approach, the module was evaluated using the validated Student Perceptions of Research Integration Questionnaire, together with additional items relating to the design and delivery of the module, and open responses. It was shown that undertaking the module improved students' perception of research integration, and had raised their awareness of the value of research carried out at their university. They also agreed that they had developed the intended skills and recognised the value of these for both further study and future employment. The value of this approach to increasing student awareness of research, and the transferability of the use of REF Case Studies to other levels of university study are discussed.

Key Words

research integration; first year students; undergraduate; REF Case Studies, module design; skills development; module evaluation

Introduction

The integration of research into undergraduate teaching (the research-teaching nexus) has inspired considerable debate in recent years, with a particular focus on the potential impact on the overall student learning experience (Healey 2005; Healey et al 2010; Malcolm 2015). Healey and Jenkins (2009) designed a model to illustrate various ways in which students can interact with research during their university courses (Fig. 1), considering student introduction to both knowledge generated by research, and the activities which underpin the research process. It also considers whether the students are actively involved in engaging with research, or passively receiving information and/or skills training.

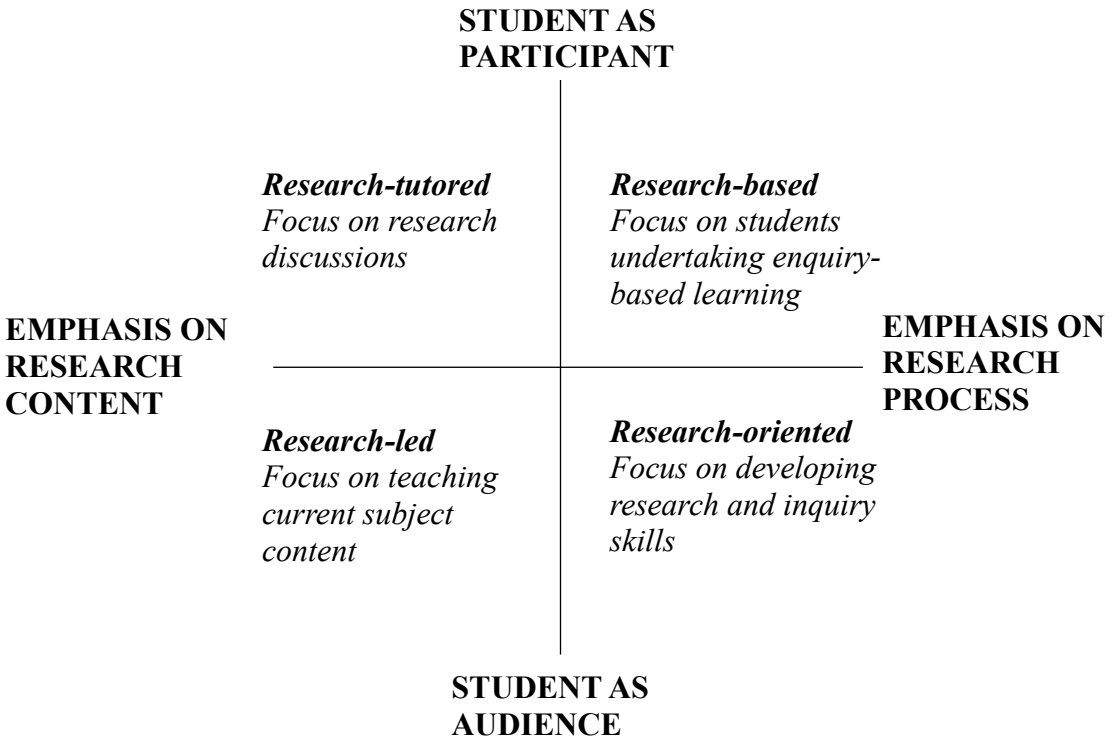

Figure 1: the teaching-research nexus (adapted from Healey and Jenkins 2009: 7)

There are many examples of students becoming involved in the research process during undergraduate studies. Final year undergraduate research projects are frequently considered as a 'capstone' experience in UK degree programmes. Seymour et al.(2004) highlighted the benefits that students perceive from participating in research projects: these included improving a range of 'research skills', such as critical thinking, problem-solving, and subject specific skills e.g. lab techniques, together with providing a sense of confidence in being able to conduct research and 'feeling like a scientist'. Russell, Hancock and McCullough (2007) showed an increase in interest in STEM careers resulting from participation in undergraduate research, suggesting that these experiences may have profound effects on the aspirations of participants. A study by Verburgh and Elen (2011) emphasized the importance of research integration, and awareness of the research carried out by staff in their own Faculty in developing student appreciation of the research process.

Most participative experiences of research, however, tend to occur during the later stages of degree courses. For many first year students, contact with research tends to focus on the elements described by Healey's model as 'Students as Audience'. Vereijken et al. (2016) observed that first year students experienced little opportunity to participate in research. Research findings are often introduced in the context of explaining how techniques or particular researchers have contributed new knowledge, rather than broader aspects of the research process, and the impact research can have beyond the provision of

new knowledge. It is often only in the final years of degree programmes that students encounter much information about the research undertaken by their lecturers. Spronken-Smith, Mirosa, and Darrou (2014) note that first year students are less aware of their Faculty's research than those in higher years, and Healey et al (2010) also noted that student awareness of staff research was shown to be skewed, with awareness increasing during the later stages of students' undergraduate programmes. This may relate to academics' perception of the linear nature of undergraduate courses, with the early years being devoted to the acquisition of knowledge, while knowledge creation is seen as an activity best suited for later stages of degree programmes (Zamorski, 2002).

Zamorski's project, which explored attitudes of both staff and students to research-led teaching suggested that students describe varied experiences and understanding of research. Often student felt frustrated by their lack of understanding of research in their university, and noted that they had a limited understanding of the research process and the nature of academic work: student researchers on this project suggested that explicit support was needed to ensure that students recognized research in their university.

Studies have been undertaken to investigate student perceptions of research, and its integration into undergraduate teaching. Healey et al. (2010) used a mixed methods approach, utilising both a quantitative survey and qualitative data from student discussion groups, while more recently, Visser-Wijnveen, van der Rijst, and van Driel (2016) have published a validated questionnaire which aims to capture a range of student attitudes towards research using a series of subscales including 'reflection on research, participation in research, 'motivation' and 'awareness of current research', all of which form part of an overall 'rating' for research integration which can be applied to courses or modules.

An opportunity to increase student awareness of current research, and its value beyond that of providing new knowledge has arisen through the introduction of the Research Excellence Framework in the UK. The 2014 UK Research Excellence Framework exercise (REF2014) introduced an assessment of research impact as part of the evaluation of research quality in higher education institutions. Units were required to submit a number of four page Case Studies which 'describe the underpinning research, include references to one or more key research outputs, provide evidence of the quality of that research, and explain how that research underpinned or contributed to the impact' (HEFCE 2012: 29). Following REF2014, Case Studies documents have been available from the REF website (http://impact.ref.ac.uk/CaseStudies/).

This article describes the design, delivery and evaluation of an enquiry-based module, based on Impact Case Studies from REF which aimed to help first year undergraduates at a UK university engage with research undertaken within their Faculty, while developing skills which would support their subsequent studies. The module aims to give students opportunities to investigate examples of the varying ways in which scientific discoveries are made, how this knowledge can be exploited to solve problems, and so have a positive impact on society, in the context of work undertaken in their own Faculty From the

perspective of Healey and Jenkins' model, the module aimed to deliver a learning experience which is research-led, research-oriented and research-based.

Module design, delivery and assessment

Four REF case studies from the Faculty of Biological Sciences at a research-intensive UK university were developed to form a module aimed at any student within the university, with no prerequisite requirements. Case studies (Fig. 2) were chosen to illustrate a wide range of research topics, from molecular studies to ecology, featuring work on diverse organisms, including viruses, plants, animals and humans. They also aimed to explore different types of impact, including commercialisation, creation of diagnostic and patient/carer support resources, and changes in government and industrial policy and practice. Emphasis was also placed on showcasing the importance and diversity of collaborations in modern research practice in STEM.

Biosecurity and sustainable tourism in the Galapagos Islands

http://impact.ref.ac.uk/CaseStudies/CaseStudy.aspx?Id=8322

Development and commercialisation of dCELL® Regenerative Biological Scaffolds for soft tissue repair

http://impact.ref.ac.uk/CaseStudies/CaseStudy.aspx?Id=6340

Technologies to control plant parasitic nematodes

http://impact.ref.ac.uk/CaseStudies/CaseStudy.aspx?Id=6318

The Leeds Consensus Statement: A universal standard to diagnose and assess Developmental Coordination Disorder
http://impact.ref.ac.uk/CaseStudies/CaseStudy.aspx?Id=6373

Figure 2: REF Impact Case Studies chosen for development into teaching materials

Each case study was used to develop an interactive pdf workbook, which included links to existing background materials available on the internet. Workbooks include links to introductory materials, and a series of tasks in the form of questions to guide students through the material provided. The academics responsible for submitting the case studies recorded 3-5 short (10 minutes maximum) illustrated talks explaining their work, which were uploaded into the university virtual learning environment and linked to the workbook. For each workbook, an on-line quiz, with feedback, was provided to help students assess and develop their understanding of the key points in the Case Study. As the module is intended for first year students, most of whom were studying in a Faculty of Biological Sciences which delivers a wide range of programmes from the highly molecular (e.g. biochemistry) to ecology, and some of whom may be studying in different faculties, hence may have significantly different academic backgrounds, the questions in the workbooks aimed to help students gain a basic overview of the research techniques utilised in the studies. Emphasis is placed on the way in which the research process is

used to tackle an identified problem, and how collaborations between scientists in different specialisms, industry, governments and NGOs were key to facilitating the impact of the research.

A ‘Getting started’ booklet was also produced, providing an overview of the module and guidance on, and links to support for the tasks (effective teamwork, writing reflectively, preparing and delivering oral presentations) that formed part of the module. This resource highlighted the value of each of the skills that students would be developing, both in relation to their future studies, and to the value placed upon these skills by future employers (Rayner & Papakonstantinou 2015). At the end of each case study, students were asked to complete a short survey on the distribution of work within their teams, allowing intervention by the module leader if problems were reported.
All the information associated with the module was delivered via the virtual learning environment. This, together with the low level of compulsory contact time, helped to ensure that the module was available to as any students as possible, avoiding timetable clashes.

Students were grouped into teams of 3-4, and each case study workbook was scheduled to be completed by the group within a 2 week period, followed by the submission of a group written assignment. Groups were encouraged to collaborate through face-to-face meetings or virtually via on-line discussion and file-sharing facilities available on the VLE or by using Facebook-type groups, to discuss the workbook, support one another and share information.

Towards the end of each two week period, a 1 hour Q&A session was used to support students, and answer questions arising from the material or the forthcoming assignment: this was then followed by a further hour, during which groups worked on producing their group assignment. At the start of the module, and after each Case Study, students were asked to write and upload a short individual reflection on different aspects of their experience such as their initial expectations, hopes and any concerns that they has as they started the module, and their experiences during the module such as experience of working in a team, and using a range of different types of resources for researching new information. The delivery of each Case Study is summarised in Figure 3.

Week 1
- Work as a team to complete workbook

Week 2
- Complete on-line quiz individually to check understanding of key points
- Attend contact session to ask questions, ensure full understanding, discuss written task
- Work in group to complete written assignment
- Complete survey of team working & upload reflective entry

Week 3
- Submit written assignment (Monday)
- Begin next Case Study

Figure 3: Delivery of Case studies

The module was assessed predominantly (70%) through group assignments, which included a written assignment and a group oral presentation on one of the case studies. Individual assessment (30%) included the submission of a reflective essay at the end of the module, together with an assessment of 'process' which took into account engagement with the tasks, effective teamwork and communication, and attendance at contact sessions. The written assignments associated with each case study aimed to encourage students to write for different audiences, and included a press release, news article for a scientific magazine, podcast script and patient/carer leaflet. Students were given formative feedback on the first assignment, then one of the following three assignments was chosen randomly at the end of the module for summative assessment. The reflective essay required students to reflect on their overall experience of the module, using the entries made during the course, including their initial perceptions and expectations of the module, the skills they had developed, how they aimed to use these improved skills, or change their approach to tasks in the future as a result, and the extent to which their initial expectations and concerns had been justified. Oral presentations titles addressing various aspects of each case study were assigned to groups and delivered during the final two week period of the module.

Module evaluation

The module has run in two consecutive years, with a total of 59 students undertaking the course. The majority of students (87%) were from Faculty of Biological Sciences, with the remaining students registered in other Faculties, or students on Erasmus or JYA programmes. Ethical approval for this evaluation study was obtained from the Faculty Research Ethics Committee.

Student perceptions of the integration of research in this module were assessed using questions selected from the Student Perceptions of Research Integration Questionnaire (SPRIQ) (Visser-Wijnveen, van der Rijst, and van Driel 2016) via a paper-based survey delivered at the first and final sessions of the module. The items related to the 'participation' subtheme of the original questionnaire were omitted, as they were not

relevant to this scenario, and 'quality' because this was assessed through routine module feedback surveys. The questionnaire uses a 1 (strongly disagree) - 5 (strongly agree) Likert scale.
Statistical comparisons were made using SPSS, and the Wilcoxon Signed Rank test.
At the end of the module, students were also asked for their opinion of the structure and assessment strategy of the module, the extent to which they had developed relevant skills, and their perception of the importance of these for future study and employment, using the same Likert scale for responses. A 'free comment' box asked students for their qualitative views on any aspect of the module.

ITEM	PRE MEAN	POST MEAN	p
I assimilated knowledge about research findings*	3.35	4.14	0.002
I learned to pay attention to the way research is carried out*	3.35	4.14	0.002
The scientific research process was an essential part of the curriculum*	3.44	4.24	0.003
I was inspired to learn more about this discipline	3.50	3.69	0.335
Links to current research practices were made*	3.53	4.14	0.003
Attention was paid to research methodology	3.45	3.79	0.151
I became familiar with research carried out by my teachers*	3.15	4.03	0.001
I became familiar with the results of scientific research*	3.42	4.34	0.000
I felt involved in the Faculty's research culture*	2.53	3.55	0.000
My awareness of the research issues that scientific researchers are currently contributing to was increased*	3.26	4.25	0.000
I learned what kind of studies have been carried out in my field*	3.58	4.38	0.001
My interest in research in this area was increased*	3.26	3.97	0.015
I learned the ways in which research can be conducted in this field	3.67	3.93	0.219
Research Integration (ALL ITEMS)	3.36	4.13	0.001
My learning is stimulated when education is grounded in research	3.44	3.83	0.172
It is important to me that my teachers conduct research	3.32	3.52	0.325
The research culture in the Faculty stimulates my learning process	3.35	3.72	0.126
Education in which scientific research is central stimulates my learning	3.47	3.76	0.280

Table 1: Average responses to items from SPRIQ before and after the module. The first 13 items related to attitudes to Research integration (aggregated to form a single value for Research integrations as a whole), while the final four relate to beliefs about research integration. *Difference between pre- and post-module survey significant at 0.05 level.

Table 1 shows the pre-and post-module scores for items from the SPRIQ. The response rate was 95%. Cronbach's alpha for the 13 items associated with research integration was 0.83, and for the four items associated with beliefs about research integration it was 0.78. Of the 13 items relating to research integration, all except three ('I was inspired to learn more about this discipline ', 'Attention was paid to research methodology' and 'I learned the ways in which research can be conducted in this field') show a significant increase after completion of the module. Conversely, none of the items in the 'belief' subtheme showed a statistically significant increase, though all showed a small increase after the module. Free comment suggested that students had been surprised by the contribution of academics within their own Faculty to research that had global impact. Several also commented that it made their choice of degree seem worthwhile, and for some it clearly reinforced their enthusiasm for a research career.

"My excitement for conducting research has increased, and I'm now more confident than ever that this is what I want to do with my life".

Students were asked to reflect on the skills they had developed during the module, and their perception of the importance of these skills, both for their future studies and for employment (Table 2).

Skill	I have improved my ability	Skill is important for future study	Skill is important in employment
	% agree		
working in a team	96.3	96.3	100.0
writing for different audiences	92.6	81.5	74.1
designing/delivering oral presentations	81.5	92.6	85.2
reflecting on my learning	85.2	77.8	77.8

Table 2: Student perceptions of their skills development and the importance of skills developed during the module

Over 80% of students agreed that they had improved key skills during the module, and the majority felt that these skills were of value both for their future studies and in the workplace. Teamwork was considered the most important skill, and the one that they had developed most. The skill that fewest students (78%) thought important for their future studies was reflection on learning, while fewest (74%) felt that writing for different audiences would be important in employment. Free comment suggested that many

students had initial concerns about working in teams, but that these reduced as the module progressed, as a result of increased confidence and improved communication between team members. One student commented:

"*This module has proven to me that group work does not have to be intimidating"*

Student opinion on the delivery and assessment of the module (Table 3) suggested that students had found the unusual format beneficial.

ITEM	% agree
I have enjoyed researching information rather than being provided with it through lectures	81.1
Researching the information for myself has helped me engage with the module content	86.5
I have received enough support from staff during the module to ensure that I have understood the material covered	73.6
Working as part of a team has improved my learning during this module	81.1
I have enjoyed working as part of a team during this module	86.8
All members of my team have made an equal contribution to the assignments	86.8
Having a timetabled session for team working has helped my team work together effectively	81.1
I am confident that the mark I receive for this module will be representative of the effort I have put in.	84.9
I would prefer a higher proportion of the module assessment to be individual, not group assignments	49.1

Table 3: Student evaluation of the delivery and assessment of the module

Most had enjoyed and felt engaged by the research tasks, and the opportunity to work as a team. However, almost half the cohort would have preferred more individual rather than groups assessment, despite a high level of agreement that team members had made equal contribution, and that their module mark would be representative of the work they had undertaken.

Free comment also suggested that a number of students were initially sceptical about the value of reflection on their learning, a task that only a small number had encountered previously. However several commented that they had found it helpful:

"The reflective log .... I felt it was going to be a waste of time .... . However ... found it useful to look back at what happened and how I think I've improved ... I am able to think about what I could've done differently.... I have learnt a lot about myself and my abilities"

Discussion

This project aimed to develop and evaluate a module intended to improve students' understanding of local research outputs, and enhance their sense of research integration into their courses. The module content was based on a selection of Impact Case Studies submitted by the Faculty to REF2014.

The 'partially flipped' design of the module was chosen for a number of reasons. From a practical perspective, the use of on-line delivery of materials had two particular advantages. Firstly, it allowed the students access to recorded material provided by the researchers who had undertaken the research which was reported via REF2014. Arranging face to face lectures for first year students from senior researchers has previously proved difficult, owing to their extensive research commitments, and existing teaching load within their individual Schools: using prerecorded material has allowed their work to be accessed by first years across the Faculty. Additionally, the provision of material on-line reduces the problem of timetabling multiple lecture sessions at times that are available to all students. From a pedagogical perspective, there have been numerous studies which have reported positive outcomes in terms of academic achievement and improved student engagement from the use of flipped classrooms (e.g. Mok 2014, Ferreri and O'Connor 2013), although risks associated with this approach have been identified (Wanner and Palmer 2016). Given that these are first year students, and that flipped learning is still relatively uncommon at our institution, regular contact sessions were included to ensure that students remained engaged, and had opportunities to check their understanding of the material: this aspect of the module design might be of less value to more experienced undergraduates, and a fully flipped module might be equally effective.

The Cronbach's alpha for the items chosen from the original SPRIQ to represent research integration is very similar to that of the original survey items (Visser-Wijnveen, van der Rijst, and van Driel 2016), suggesting good internal consistency despite omission of some of the items.

Values for most individual items, and for Research Integration as a whole suggest that even before the students undertook this module, they had a relatively strong awareness of research integration within their Y1 courses. Direct comparison with the results reported by Visser-Wijnveen, van der Rijst, and van Driel (2016) is not necessarily valid, since a modified form of the survey tool was utilised in this study, but it is noticeable that in general, scores both before and after the delivery of the module seem higher than those reported for a range of courses in this group's institution. This may be due in part to the omission of the items associated with the Participation subscale, which attracted particularly low scores in most of the modules studied by this group, but may also relate to a strong belief in the value of research in supporting and motivating student learning,

as evidenced through relatively high scores for the items which fall into the 'beliefs' subscale. Visser-Wijnveen, van der Rijst, and van Driel (2016) comment that the value of the beliefs subscale is that these items correlate with the Research Integration scale: where values for items on the belief subscale are high (indicating that students value research as important for their learning), this would positively affect Research Integration scores. The relatively high values for items in the beliefs subscale may therefore underpin the high scores observed in other items.

By far the lowest scoring item before the module was 'I felt involved in my Faculty's research culture' which would support the observations that first year students often feel remote from the research undertaken by Faculty staff (Healey et al, 2010, Spronken-Smith, Mirosa, and Darrou 2014). While this item score increased significantly after the module, it remained the lowest-scoring item: although progress has been made in increasing students' sense of involvement, this is likely to require further reinforcement as their courses progress.

The scores on most items increased significantly when the survey was repeated at the end of the module, suggesting that the module succeeded in raising student awareness of specific aspects of research integration. Two of the three items which did not increase significantly related to research methodology, and this probably accurately reflects the limited emphasis on the research methodologies encountered by students. As this module was intended to be available to students with or without a scientific background, and from a wide range of biological science subject areas (ranging from biochemistry to zoology), a deliberate decision was taken to expect students to demonstrate a general understanding of techniques, rather than a detailed knowledge. The third which did not show a significant increase item ('I was inspired to learn more about this discipline') may be explained by the diversity of the cohort, most of whom would not identify with the all specific disciplines exemplified by the Case Studies.

Student comment clearly demonstrated that students felt that their awareness of research undertaken by staff at their own institution had increased, and for some, that this had a significant impact on their attitude towards their degree programme, and the staff who taught them, as was also observed by Verburgh and Elen (2011). For some, it had also increased their interest in a research career, in agreement with the findings of Russell, Hancock and McCullough (2007).

High levels of agreement with items relating to students' experience of teamwork on the module, and their recognition of this skill for both study and employment were observed. Free comment suggested that many students had started the module feeling anxious about working in a team, but had gained in confidence as the module progressed, referring to advantages such as increasing their motivation to complete tasks, and the opportunity to share different ideas and working practices. Although many studies have demonstrated the positive value of team-working experiences at university, they also note areas of dissatisfaction, particularly around unequal contribution of team members, communication difficulties, and the allocation of marks failing to reflect individual input (Hansen 2006, Kapp 2009, Wilcoxson 2006). While no face-to-face training was offered

to enhance teamwork at the start of the module, the availability of on-line resources, together with monitoring of team activities, and providing regular opportunities for students to report concerns via a confidential online survey appears to have allayed most of the regularly-observed concerns around teamwork and assessment. Several students also noted that this experience of teamwork differed from those they had previously encountered because they worked with the same team for a prolonged period, which allowed trust and confidence to grow. Improved student satisfaction relating to team-based assignments on university programmes may result from allowing students to work in the same team for multiple activities.

However it is clear that almost half the students would have preferred a greater degree of individual marking, despite the majority feeling confident that their marks would be representative of the effort they had put in, and feeling comfortable in the team environment. For future iterations of the module, comments from previous students about their initial concerns around teamwork, and collaborative assessment, and the advantages they identified of collaborating on assessed work, together with more explicit advice around effective mechanisms for co-creation of written work will be provided during the introductory talk. In an environment of increasing student numbers, efficiencies in teaching and assessment are vital, so a better understanding of student concerns in this area, and how to ameliorate them would be helpful. This will form a future research project.

Encouraging and assessing critical reflective practice, while common in degrees which lead directly to professional qualifications such as healthcare and teaching (Mann, Gordon, and MacLeod A 2009, Beauchamp 2015) is uncommon in STEM subjects, though reflection forms a key part of the Kolb cycle (Kolb 1994), which is often used to describe the processes of experiential learning. Consequently, students were provided with guidance on reflective practice, together with examples of good and less good reflective essays, in order to ensure that they had a clear understanding of what was expected. The inclusion of practice and assessment of reflection in this module aimed to support first year students in developing an analytical approach to learning experiences which has been shown to support development of self-regulated learning (Pretorius & Ford 2016). While this was a new experience for almost all the students, and was met with initial scepticism, more than three quarters of the students recognized its value for both future study and employment, suggesting that the module had achieved its aim of helping students develop this valuable skill. Similar assessments may be of value in future modules to consolidate reflective skills.

In recent years course-based undergraduate research experiences (CUREs) have been introduced to a range of STEM courses, as a way of giving larger groups of students the opportunity to experience the research process. These courses focus on providing laboratory-based experiences which give students an authentic opportunity to research a ‘real’ problem, and potentially add to current scientific knowledge, and promote integrated understanding of the research process (Linn et al. 2015). These have been shown to have positive outcomes for both student performance and engagement (Auchinloss et al. 2014). The module described here has been shown to provide similar

benefits in a non-laboratory environment, so providing a possible alternative approach to enabling large numbers of early stage undergraduates to gain an understanding of the research process.

This is a relatively small study at a single institution, and results may not be applicable in all HE contexts, however results suggest that this module has succeeded in improving first year students' appreciation of research undertaken by their own Faculty, and research integration into their programmes. It has provided insights into the nature of modern STEM research, and the many ways in which research has impact beyond simply adding to the knowledge and understanding of the subject area, thus extending students' understanding beyond the outputs of research with which they are most familiar at this early stage in their degrees.

Educational implications

REF Impact Case Studies are designed to deliver a concise 'non-specialist' overview of successful research projects complete with relevant references, making them ideal for further development as re-useable educational resources.

Engaging first year undergraduates with research is a challenge for many undergraduate programmes. This study has shown that with appropriate scaffolding, such materials allow first year students to access and understand the impact of research undertaken by staff within their own Faculty, which has positive effects on students' recognition of research integration, with implications for improved engagement and career aspirations.

However, while the module described in this study was designed for first year students, the use of REF Case Studies to create teaching material is not limited to this setting: it would be straightforward, by altering the background materials provided, the tasks set for students (including, for example critical analysis and a deeper understanding of study design and methodology), and the degree of support provided, to create materials for use at different levels of study, both undergraduate and postgraduate. Materials can be packaged into modules for semi-independent study, as described here, or delivered as individual unit within existing programmes.

The design of the materials in a 'flipped style' together with group assessment allows the teaching model to be scalable for greater numbers, without excessive staff workload, and ensures input from highly successful and busy academics into undergraduate teaching, which can prove challenging. Inclusion of a strong emphasis on skills development has also demonstrated benefits, recognized by participants.

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