Enhancing the teaching-research nexus in the undergraduate curriculum through assessment

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Abstract

Successful linkages between teaching and research in the undergraduate curriculum are strongly dependent on academics' ability to encourage and facilitate an inquiry based approach to learning. An assessment strategy in which students become active participants in the assessment process is crucial to facilitate the development of this inquiry based approach. Developing this so-called research-mindedness is central to helping students' to become independent learners and to be more effective professionals in their future careers. This paper describes a distributed systems approach to assessment implemented in the undergraduate module Molecular Biology. The assessment comprised a series of sequence identification, database use and analysis steps, with each student being given a different starting gene. In combination, the students analysed an entire genetic pathway. This approach allows the assignments generated to be combined and used to address a single larger question, which can be either teaching or research based. This is then fed back into the teaching. This direct link between the assessment outcomes and the learning process increases student engagement with the subject and sense of ownership of the work carried out. This approach to assessment, in which students undertake a small part of a larger task, is ideal for various technical, skills-based, assignments, such as those central to the many types of bioinformatics analyses. However, it can be adapted to various types of meta-review. The paper discusses the details for the implementation, as well as the benefits and potential pitfalls of the approach.

Keywords: Research Informed Teaching, undergraduate assessment, student research-mindedness.

1. Introduction

It is a commonly held belief among academics that teaching and research have a mutually reinforcing, synergistic relationship [1, 2]. Furthermore, the view that teaching effectiveness is directly linked to research excellence underpins the foundation of research universities [3]. This belief is however largely unsubstantiated by research and scholarly evidence, and there is no *a priori* reason why a good researcher will make a good teacher. Indeed, in a meta-analysis of measures of research output (including quality, productivity, citations), and teaching quality (student evaluation, peer ratings) in both teaching- and research-oriented universities, Hattie and Marsh [2] found zero correlation between teaching quality and research excellence. Hattie and Marsh concluded that "the common belief that research and teaching are inextricably entwined is an enduring myth. At best, research and teaching are very loosely coupled" [3]. Further, many students only have a limited exposure to research, with their final year individual study or honours project forming the major component of the research-led teaching and the most important part of the link between teaching and research [4].

This lack of a demonstrable link between teaching effectiveness and research excellence, and the limited research experience of many students does however conflict with the value student place on learning in a research-based environment, and the benefits that research active staff can find from undergraduate students [5]. There is also the issue of how the "enduring myth" of the relationship between research and teaching excellence has been created, with researchers suggesting that this it arises as "universities use research as an advertising lure," "academics use research output as market commodities," and "because most academics would like it to be true" [2]. Some authors have gone even further and postulated that often research and teaching can be in competition or even conflict [6]. For academics, the time spent on research is time taken away from teaching, and vice versa. Students are often affected by the negative aspects of research (e.g. lack of availability of staff heavily involved in research), and may develop the perception that they are not stakeholders of research, but mere recipients of it [5, 6] .

This lack of correlation between teaching and research excellence has been used to justify the separation of teaching and research for funding purposes, and the establishment of "teaching only" universities. However, none of the research has concluded that teaching cannot or should not benefit from being linked to research [1]. The fundamental issue is what Higher Education institutions wish this relation to be, and then provide the conditions for this wish to be achieved [3]. According to Hattie and Marsh, "The aim is to increase the circumstances in which teaching and research have occasion to meet, and to provide rewards not only for better teaching or for better research but for demonstrations of the integration of teaching and research" [2]. Establishing a successful link between teaching and research is neither simple nor automatic, and they are strongly dependent on academics' ability to encourage and facilitate an inquiry based approach to learning [1, 7, 8]. This must therefore be embedded at the curriculum design level and can develop students' ability to understand and carry out research, providing the desired link between research and teaching [7]. The focus must shift from teacher excellence to the student learning experience. The challenge is not to focus on the differences between teaching and research, but to look for potential synergies between both activities, and how these can be integrated in the undergraduate curriculum.

Student work tends to be almost completely dominated by assessment [9, 10]. Actions that enhance an inquiry based approach to learning in the assessment strategy of a given course or module seem an effective way of developing the teaching-research nexus. Assessment provides reliable information on student performance; moreover, it also has an important formative aspect, which can be used very effectively to enhance student learning. Ideally, students become active participants in their own assessment, and this active role then helps them to become independent learners and effective professionals. The goal is therefore to design assessment strategies that are flexible enough to require minimal changes from one cohort to the next, challenge students and meet the desired learning outcomes at the appropriate level for a particular module [11]. However, focusing on the student experience should not be detrimental for the lecturer. Any assessment regime must be carefully designed so it can be easily managed by the lecturers concerned, and does not result in unacceptable marking loads. As Gibbs and Simpson say, "The trick [...] is to generate engagement with learning tasks without generating piles of marking" [9].

Herein we describe the way research and teaching have been integrated in the assessment for the undergraduate module Molecular Biology, by implementing a distributed systems approach to assessment. The paper discusses the details for the implementation, the benefits and the potential pitfalls of the approach.

2. The assessment strategy

This assessment was implemented in the undergraduate module Molecular Biology. This is a second year module (10 ECTS credits), compulsory for those students enrolled in the Bioscience BSc. The module aims to introduce students to the main theoretical concepts and practical applications in molecular biology, as well as to provide them with a range of sound practical skills in the field of biotechnology. Theory sessions (24 hours) provide background information and context for the practical sessions, and involve the use of on-line bioinformatics resources to introduce these important tools and to contextualise the practical work. The module also comprises 40 hours of laboratory practicals, which run over the course of 8 days, involving a wide range of both DNA and protein analysis techniques. Approximately 40-50 students are enrolled in the module on any given year.

Molecular Biology is assessed entirely by continuous assessment. The assessment strategy comprises a lab book (40% of the total mark for the module), an essay (30%), and a computer exercise in which students are given a list of tasks to carry out using on-line resources (30%). It was on the computer exercise where we decided to introduce this distributed systems approach. Each student is given a different starting gene, and the assessment comprised a series of sequence identification, database use and analysis steps. In combination, the students enrolled in the module analysed an entire genetic pathway. In this instance, students were each given one gene from the well characterised pathway that controls the switch between dauer and non-dauer larval development in the free-living nematode *Caenorhabditis elegans* (for background on the control of dauer larvae development see [12-14]. Students had to recover the nucleotide and amino sequences of their gene, use a variety of database search tools to identify orthologous sequences in other nematodes, and then undertake phylogenetic and molecular evolutionary analyses of these sequences using MEGA version 4 [15]. Throughout the assignment, students were required to record the hyperlinks of pages from which sequences were obtained, and both record and interpret the results of their analyses. After completing the exercise students had to compare and contrast the results of their analyses with the specimen example provided.

3. Results and discussion

There are multiple benefits associated with this assessment approach. It is very effective at designing out plagiarism, since students are undertaking the same set of tasks, but with a different starting gene. The approach does however encourage collaboration, as students can help each other with aspects of the assignment without fear of committing unintentional plagiarism. A model worked example of the assignment can also be presented to students, which gives them a clear idea of what is expected from them. The positive aspects of this particular assessment strategy also extend to the lecturers involved in the marking process. All students produce a "different" assessment, thus avoiding the repetitive, often "soul-destroying" activity of marking numerous copies of almost identical assignments. At the same time, the assignment tasks are the same for each student; this means it is still possible to set up a structured, straightforward, easy-to-use marking scheme, therefore avoiding the generation of an unmanageable marking load. On this particular case students were asked to submit their work electronically, which allowed for the inclusion of hyperlinks and results embedded in their assignments. This allowed the marker to establish a clear separation between assessing the tasks undertaken and the subsequent interpretation of the results. Thus, students could still be given credit for correctly interpreting the results of an incomplete or even incorrect analysis. The assessment contributed to the generation of a number of interesting research questions, and a follow up session was organised to discuss the wider questions about the evolution of genetic pathways that arose from the body of data generated by the students.

There are however potential pitfalls with this approach. If the assignment is not set up correctly, there is the risk of generating an unmanageable marking load. It is important to make sure that students are required to submit sufficient evidence so their analysis can be followed by the marker. If this level of detail is not provided, then there is the potential danger of the marker having to repeat the students' work. It is therefore essential that the assessment instructions are very clear, so students know what is expected of them; in our case, we also decided to provide a worked example of the assignment. It is also important that the use to which individual assessments are put is clearly explained as without this explanation there is a risk that the further use of the assignments will conflict with the student's emotional investment in their work [16] and actually decrease the ownership felt.

4. Conclusions

This paper described a distributed systems approach to assessment implemented in the undergraduate module Molecular Biology. The assignment comprised a series of steps including sequence identification, database use and analysis. Each student was given a different starting gene and, in combination, the student cohort analysed an entire genetic pathway. The assessment designs out plagiarism, while facilitating collaboration and teamwork. A worked example of the assignment was provided, which helped students understand the marker's expectations and assisted with the task. The body of knowledge generated fed back into the teaching, increasing student engagement and ownership, and fostering the students' research-mindedness. Inquiry-based learning is at the heart of this assessment approach. It is highly suited to technical assignments carried out in bioinformatics, as well as any other practical based analyses which are reliant on large scale repetitive assays, e.g. toxicology screens, mutational analysis, or the phenotypic screening of inbred lines. Additionally, this approach would also translate well to the production of meta-reviews, with each student assigned a particular journal or keyword. In some cases, this assessment approach could directly generate publishable work.

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