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From the International Desk

Scaffolded Reflection as a Tool for Surfacing Complex Learning in Undergraduate Research Projects

Abstract

Undergraduate research experiences (UREs) are often designed so that the student undertakes a small research project and presents it in a professional format. While this develops skills in research and presentation, it may also focus student attention on the output of the research—the results or findings. Students therefore may undervalue learning about the process of research, even though such learning is usually highly valued by their supervisors. This article describes an intervention aiming to direct students' attention to the research process by incorporating structured reflection into their experiences. Our intervention involved the implementation at three contrasting universities in Australia of a private blogging system, in which students responded to prompts about their research. The questions were designed to focus students' thinking on the nature and practice of research and on their own learning. The research experiences included stand-alone, immersive projects, as well as scaffolded experiences embedded in conventional coursework in science, arts, and social sciences. We found that the blogs could be used to elicit evidence of particularly complex learning outcomes such as critical, independent, and creative thinking, and improved understanding of the nature of the students' disciplines. We also describe some of the practical aspects of the system's implementation and use, including challenges such as maintenance and levels of openness. We conclude that, although somewhat complex to introduce, the process of structured reflection adds significant value to UREs.

Design of Undergraduate Research Projects that are Assessed for Degree Credit

Providing opportunities for undergraduate students to engage in research is widely seen as desirable for a variety of reasons, including improved connections between a university's research and teaching activities, improved student motivation and retention, and valuing students' learning about research (Howitt et al. 2010; Hunter et al. 2006; Kardash 2000; Linn et al. 2015; Lopatto 2007; Russell et al. 2007; Seymour et al. 2004). Students may benefit by deepening both their knowledge of their discipline (the questions currently preoccupying it, the methods available to address those questions, the kinds of evidence seen as valid) and generic skills (problem-solving, critical and analytical thinking, independence, and creativity). Thus there are very good reasons to promote a variety of research experiences, spanning the spectrum from individual supervised projects to structured, course-based activities, as normal components of the undergraduate curriculum. However, once such experiences become graded activities that contribute to a student's GPA, new questions arise regarding their design, supervision, and assessment, as well as what they contribute to students' learning outcomes.

In the following, we focus mainly on apprentice-style undergraduate science research experiences (UREs). Supervisors and other faculty may hope that UREs will facilitate rich learning about the complex nature of research and lead to development of professional research expertise (Wilson et al. 2015b), including the ability to generate and frame research questions, as well as understanding the necessity of adopting a critical stance regarding one's own methods and data, of being simultaneously rigorous and flexible, and of making judgments and decisions at all stages of the research process. However, although many students who undertake UREs report "learning what research is like" in general terms, only a very few appear to attain high levels of understanding of the nature of research (Howitt et al. 2010; Hunter et al. 2006; Kardash 2000; Linn et al. 2015).

This suggests there is a need to reconsider the structure and assessment of research experiences to focus on developing professional expertise in addition to disciplinary knowledge and skills. Developing from novice to expert researcher requires a sense of the interconnectedness, incompleteness, contingency, and ambiguity of current knowledge, in addition to the disciplinary context. It thus requires the development of the kinds of "wicked competences" (Knight and Yorke 2008) that are needed to recognize, understand, and address "wicked problems." We argue that if UREs are to be made more effective in encouraging steps along this novice-to-expert transition, we need to pay attention to two key issues: re-aligning assessment and assuring high-quality supervision.

Assessment is widely acknowledged to drive learning, and the effective constructive alignment of assessment activities has been demonstrated to result in improved learning outcomes (Biggs and Tang 2011). UREs, however, are often assessed primarily through a final report based on a scientific paper. As

we have argued elsewhere (Howitt and Wilson 2014), this is typical of much science education in which there is a focus on the outputs rather than on the process and practice of science. Textbooks and scientific papers give what appears to be a complete story, but conceal the process of discovery, leaving the misleading impression that knowledge is certain. Project reports modelled on such formal academic communication may therefore result in students' attention being focused on experimental outcomes (Wilson et al. 2015b), rather than on seeing the practice of science, including the inevitable troubleshooting and cycles of experimental design and re-design, as part of their learning. Problems may be seen as delays in getting results rather than as opportunities for learning. Some form of activity that allows students and their supervisors to recognize and value learning about the process and practice of science could be a valuable addition to the assessment that leads to grading of a URE.

The supervisor of a research project is key to the success of the experience for the student (Howitt et al. 2010; Lopatto 2003; Russell et al. 2007). Research projects that are done for degree credit occupy contested ground for the supervisor, somewhere between a teaching experience with a focus on student learning and a contribution to the supervisor's program of research with a focus on the results obtained. Where the supervisor sits along this continuum will have a big impact on his or her approach to supervision. Although we might expect that the focus would be on student learning outcomes, our experience with a research-intensive undergraduate degree shows that this may not be the case (Howitt et al. 2010; Wilson et al. 2012). Interviews with supervisors revealed that while most valued development of "wicked" competences and an understanding of the nature of research as learning outcomes for their students, they agreed that these outcomes were difficult to assess (Wilson et al. 2015b).

Instead, supervisors often rely on under-articulated "markers for growth" (Laursen et al. 2010, 170) to make judgments of student progress and achievement. However, these do not provide the kind of evidence on which effective teaching interventions or grading decisions can reliably be made. Thus, supervisors experience a lack of clarity both in the aims of the research project and the value of the learning experience to the student. Quality of supervision might be improved if supervisors had a greater awareness of these issues, potentially leading to greater equity in the way projects are framed, supported, and assessed.

Introducing Structured Reflection: the TREASURE project

One way in which students' attention can be focused on process and their thoughts and progress made more visible to supervisors is through the use of structured reflection. Reflection is seen as an essential component of a model for the learning cycle in inquiry-based projects (Justice et al. 2007), increasing engagement and building students' capacity for self-evaluation. Reflection can assist the students to deconstruct an experience by considering what has happened and why and thus help them to adjust to the unfamiliar demands of research or inquiry. However, students need some guidance and structure in order to reflect effectively. In addition, there is evidence that without incentive to do so, significant proportions of students do not regularly reflect on their learning (Spronken-Smith et al. 2011), and thus may benefit less from inquiry experiences than they might.

Reflective journals are commonly used during work placements and internships in professional degrees because they allow students the space to come to terms with the complexity of the workplace, by directing students' attention to the processes, interactions, and decisions that structure the workplace; they also are tools for self-assessment and ongoing development. The realization that the wicked problems of the workplace are different from the structured problems usually experienced in undergraduate courses can be difficult for students. Undergraduate research experiences share this feature with work placements and thus reflective journals are also likely to add value to the experience.

A project we named TREASURE (Teaching Research-Evaluation and Assessment Strategies for Undergraduate Research Experiences) allowed us to introduce structured reflective logbooks in UREs. Our aim was to reveal and enhance "invisible learning" by providing a scaffold for both students and supervisors to recognize and value increased understanding of the nature and practice of research and the learning of generic skills. By asking students to respond to questions regularly throughout the URE, we wanted to document their changing ideas and perceptions. Previous publications provide details of the project and our findings ((Howitt et al. 2014; Wilson et al. 2015a; Wilson et al. 2015b; Wilson et al. 2015c). Our intention here is to briefly summarize the approach and consider some implications.

The reflective journals were structured by the inclusion of questions that asked students about their learning and their experiences of research. The Prompt Question Framework (see Table 1) was developed for our project. Prompt questions need to be carefully tailored to course contexts and desired learning outcomes; while they are effective in directing students' attention toward aspects of their experience, they can also direct attention away from other aspects. The questions sow the seeds of reflection, and since students only have limited time, they are likely to reflect on what is being highlighted for them by the questions in front of them. Our questions were initially designed for science UREs and were developed after workshops and interviews with supervisors about their learning outcomes for students' projects. At the workshops, supervisors were able to suggest questions and comment on the value of existing questions. Although some