Does Formative Assessment Improve Student Learning and Performance in Soil Science?

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ABSTRACT Soil science students are required to apply knowledge from a range of disciplines to unfamiliar scenarios to solve complex problems. To encourage deep learning (with student performance an indicator of learning), a formative assessment exercise was introduced to a second-year soil science subject. For the formative assessment exercise, students were required to prepare a draft of a critical review of a current topic in soil science, and then (following guidance from staff members) provide feedback to each other through a peer assessment exercise. In contrast to expectations, the formative assessment did not appear to improve overall student performance in this task based upon their grades for this task. Furthermore, despite being given an exemplar and attending a workshop where tactics for searching the scientific literature were discussed, this did not increase the likelihood that students would cite studies from the scientific literature when conducting their critical review. Regardless of these observations, the students were positive and appreciated the feedback they received through the exercise. This study demonstrates the need to ensure that feedback is effective and enables students to identify their weaknesses and modify their work accordingly.

The discipline of soil science is fundamental and essential to maintaining agriculture, managing the environment, and supporting the economy. However, the discipline is in a critical state because of falling enrollments of students and dwindling academic expertise leading to a loss of capacity to provide the breadth and depth of knowledge required to meet the needs of the economy. Historically, soil science developed as an agriculturally based discipline, with both the teaching and research of soil science focused on agriculture and food production. However, due to slow changes in public attitudes and governmental policy, there is now also much interest in soil science from the "environmental sciences." Unfortunately, there is little information available regarding the teaching of soil science in the education literature. Like other fields, students within soil science are required to draw upon skills and knowledge from a range of disciplines including chemistry, biology, physics, geology, and agronomy. This requires the students to have problem-solving skills and an ability to apply existing knowledge to new areas.

With these challenges in mind, it is important in soil science (as it is in all disciplines) to encourage deep learning and improve student performance. Deep learning involves critical analysis, the linking of new ideas to already known concepts and principles, and leads to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts (Houghton, 2004). Compared with surface-learning, deep learning has certain characteristics, including (1) looking for meaning, (2) focusing on the central argument or concepts needed to solve a problem, (3) interacting actively, (4) distinguishing between argument and evidence, (5) making connections between different modules, (6) relating new and previous knowledge, and (7) linking course content to real life (Biggs, 2003; Houghton, 2004; Ramsden, 2003).

Formative assessment (also known as "assessment for learning") has been suggested within the literature as one method to both encourage deep learning and improve student performance. Formative assessment provides students with information about their performance, and is essentially feedback (Ramaprasad, 1983). Klenowski (2002) proposed that when such learning takes place, the learner is actively engaged and integrates the information in relation to his/ her own experience rather than memorizing the information. Formative feedback aims to provide information about the gap between the current and desired level of performance.

There are a range of procedures that can be utilized as formative assessment exercises, ranging from formal to informal. However, for students to improve, they must develop the capacity to monitor the quality of their own work (Sadler, 1989). There have been numerous reports in the literature that formative assessment is an important process to enable learning, and in particular, deep learning. Indeed, in a review of 250 articles from the educational literature, Black and William (1998, p. 139) conclude that "formative assessment is an essential component of classroom work and that its development can raise standards of achievement." Similarly, in the meta-analysis of Hattie (1987), it was concluded that "feedback" had the most powerful single effect on achievement. Indeed, some