TECHNOLOGY-ENHANCED LEARNING SUPPORTING ENGAGEMENT, ASSESSMENT, AND REFLECTION IN HIGHER EDUCATION SCIENCE

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In this paper, the results of a study conducted in higher education science across three groups of early-career scientists in the same university—undergraduate students, masters students, and doctoral students—will be presented. All three groups were taking similar versions of a Science & Society module that focused on the roles and responsibilities of scientists. The students from these groups provided short continuous feedback before, during, and after each lecture in the module, and focus groups were conducted with the students at the end of each module. The main factors being considered were the benefits and challenges of technology-enhanced learning in regards to student engagement, assessment, and reflection. This work highlighted that while the benefits are numerous, the challenges can often vary depending on the students' current level of higher education science.

Keywords: Higher Education, Technology, Reflection.

INTRODUCTION

In this study, technology-enhanced learning was compared across three different stages of higher education science: undergraduate, masters, and doctoral level. There have long been concerns about the standard of teaching in higher education science (Sunal et al., 2001). One of the ways to address such concerns and raise these standards is to integrate technology into the learning experience with the view of supporting student creativity, innovation, engagement, assessment, and reflection (Johnson & Carruthers, 2006).

The guiding research question was:

"What are the benefits and challenges of technology-enhanced learning in higher education science?"

This was tackled by breaking down the work into two sub-questions:

1. "How do these benefits and challenges relate to engagement, assessment, and reflection?"

2. "How do they compare between students in undergraduate, masters, and doctoral level courses?"

Technology was used to support engagement in this study through the use of audience response systems and virtual learning environments. In higher education there has been growing emphasis on finding ways for students to engage in lectures using their own smart devices,

such as tablets or smartphones (Stowell, 2015). This follows the gradual move away from outdated radio frequency transmitters ('clickers') towards software solutions that rely on smart devices (Kay & LeSage, 2009; Koppen & Langie, 2013). For this study, engagement was facilitated and evaluated across three levels of higher education science using contemporary audience response systems.

Both self-assessment and peer-assessment were supported through the Blackboard Learn virtual learning environment (Heaton-Shrestha, et. al., 2007). Students uploaded their assignments and then anonymously reviewed and graded their classmates' work. Technology can speed up the assessment process, which aligns with the recommendations of Brookfield (2015) who noted that when it comes to providing student feedback: "immediacy is valued by students and demonstrates your responsibleness, an important element of authenticity" (p. 192). While reflection is often used as a means of practice-based professional learning (Thompson, 2000), this process of self-assessing personal development can offer early-career scientists a way to better understand their own learning.

METHOD

This work began by carrying out literature reviews of the three chosen areas of technology-enhanced learning: engagement, assessment, and reflection. Student feedback from the undergraduate, masters, and doctoral level students was recorded using reflection questions before and after each lecture on a Science & Society module.

Before each lecture the students were asked to record their initial understanding of the concepts that were going to be covered in class. After the lecture, the students were asked to reflect on their understanding of the concept, if it had changed, as well as any aspects of the lecture that were significant to them.

One of the goals of the module was to help early-career scientists to "take responsibility for their own learning" (Hall, 1996, p. 112). The module was underpinned by a general framework of social constructivism (Hodson & Hodson, 1998), but with a focus on how values, perceptions of socioscientific issues, and ethics all play a role in creating a mutual understanding of the world around us (Arghode, Yalvac, & Liew, 2013).

The students engaged in the lectures using software called "Poll Everywhere" — an audience response system that facilitates democratic decision-making in audiences (Shon & Smith, 2011; Kappers & Cutler, 2015). The students were asked to anonymously and independently provide feedback on their learning following the recommendations of Hughes, Kooy, and Kanevsky (1997) and answered questions using their own smart devices (spare iPads were provided to students without access to a smart device of their own). This use of audience response systems is common for large-scale events such as public lectures and festivals (Roche, Cullen, & Ball, 2016; Roche, Stanley, & Davis, 2016).

Reflective practice was integrated into the module in terms of teaching (Brookfield, 1995) and the students' reflective writing assignments (Bolton, 2010). At each level (undergraduate, masters, doctoral) a representative subset of the students took part in a focus group to provide

feedback on their experience of the technology-enhanced aspects of the module. The focus groups followed the protocol described in Roche et al., (2017).

DISCUSSION AND CONCLUSIONS

As was expected, when addressing the research questions, technology-enhanced learning in higher education science posed both benefits and challenges (Table 1). Engagement through mobile technology was found to be a beneficial method of facilitating safe, anonymous, whole-class discussions in real-time. This was especially useful in large classes, and was found to be especially meaningful for participants who did not feel confident speaking out in a lecture. Such students found seeing their contributions appear anonymously on the lecture screen empowering.

For some masters students, and a larger group of doctoral students, there was a feeling that digital engagement deprived them of the opportunity to actively engage in lectures. This could be due to the smaller class sizes at masters and doctoral level, growing confidence to engage at those levels, or an average age difference compared to the undergraduate students. All of these factors are worthy of further consideration and follow-up research.

As has been found elsewhere, self and peer-assessment worked best when the students and staff jointly determined the criteria and marking rubrics (Dochy, Segers, & Sluijsmans, 1999). This is particularly relevant as many universities move more towards e-learning, distance learning, blended learning, and flipped classroom approaches. It is becoming increasingly important to understand the strengths and weaknesses of these approaches for student learning at different stages of higher education science.

Using technology to support reflection was found to equip students with valuable tools to observe, gather information, analyse, and draw conclusions on their own learning and development. Given the challenges that early-career scientists are facing (Powell, 2016; Roche & Davis, 2017) such skills are more pertinent than ever. The students responded best to having a clear model to follow.

One of the biggest challenges to emerge was balancing the burden on students to be continuously providing feedback, which was reported as more of an issue for the masters and doctoral students. The students discussed this in similar terms to the reflection "burnout" referred to by Anderson (1992, p. 308). While the drawbacks of technology-enhanced learning are smaller than the number of benefits, they could become more pronounced if several types of technology-enhancements are combined. This multiplier effect also requires further investigation. This would help form a framework for technology-enhanced learning that is determined by the needs of the students at different levels of higher education science.

Table 1. Benefits and challenges of technology-enhanced learning in relation to student engagement, assessment, and reflection.

Type of Technology-	Benefits	Challenges

enhanced Learning		
Engagement through mobile technology	Anonymity Facilitates real-time whole class discussions Empowering for less confident students More suitable for large undergraduate classes	Reduces opportunities for oral discussion in small groups (especially for postgraduate students)
Self and peer-assessment	Gives more ownership and agency to students in their assessment Reduces burden on staff to provide formative feedback	Critiquing a classmate's work can be an uncomfortable experience for some students
Reflection	Facilitates faster personal insights for students on their learning Develops critical thinking skills	Risk of reflection burnout

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