STEMming the flow: content delivery through digital media for enhancing students' construction of knowledge

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> It may be that the greatest gain in aggregate student learning in STEM is achieved not through the adoption of optimal teaching practices in each classroom but through the elimination of the worst practices (Fairweather, 2008, p. 8).

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Introduction

STEM disciplines rely heavily on the delivery of facts, formulas, concepts and definitions to lay the groundwork for later application. With the move to blended and flipped learning, teachers are being encouraged to replace the traditional face-to-face lecture with video recordings of mini lectures placed online. Students are then expected to engage with this digital media as pre-work before coming to class to actively engage with the content through collaborative activities.

This discussion paper examines the modality of content delivery in the STEM subjects and its effectiveness. During the session, participants will be guided to share ideas and practices through an online collaborative medium. The shared resources bank can then be accessed and used for curriculum design and development activities.

Background

There is widespread acknowledgement that active engagement with subject content leads to better student learning outcomes (Biggs & Tang, 2013; Kuh, Kinzie, Buckley, Bridges & Kayek, 2007; Prince, 2004). The idea of flipping the classroom is growing in popularity as curricula are redesigned to remove the didactic lecture (which may encourage passivity) and replace it with a blend of online preparatory materials followed by active, collaborative, face-to-face learning activities. However, not everyone agrees that lectures should be replaced or that they are passive instruments. For example, Richardson (2008) suggests a rethink of lecture delivery, breaking it up into smaller chunks (creating mini-lectures) interspersed with student centred activities designed to engage the students with concepts essential for understanding and knowledge creation. Nonetheless we return to the basic premise of delivering content and how students engage with it. So what makes for an effective learning experience in terms of the content delivery?

The push to blend and flip has resulted in many institutions experimenting with a variety of content delivery modes. The availability of flexible multimodal resources is a requirement of today's student. It's impossible to classify all students neatly into lecture attendees or non-attendees (Gysbers, Johnston, Hancock & Denyer, 2011) and the reasons for an individual's choice are numerous and beyond the scope of this discussion. Many students prefer the freedom and accessibility of online lectures whereas others have been known to complain when content is placed online because they feel they are being deprived. They want to hear their lecturer - the expert - provide the information directly to them (Gysbers et al., 2011). The creation of video lectures, either recording the original lecture or recording mini-lectures at the content expert's desk, in front of a webcam or in an empty room in front of a camera, has been a response to this. But the question remains; is this delivery any better (or worse) than the face-to-face (f2f) equivalent in terms of effectiveness?

Discipline based design

Pedagogical strategies most effective in enhancing student learning outcomes are not discipline dependent (Pascarllea & Terenzini, 2005). However certain disciplines such as those included in the term STEM (Science, Technology, Engineering and Mathematics) can be heavily content driven, particularly in the early stages. There is an abundance of terminology of anatomical structures, ecosystems, information systems and formulae that define actions, processes, laws and the like. Such content driven learning tends to be located in the lower order objectives categorised in Bloom's (1956) cognitive domain such as remembering, and understanding. Deeper learning takes place at the higher order objectives such as analysing, evaluating and creating, but the design of these higher order learning experiences is dependent on students having attained the prerequisite knowledge and skills (Orlich, Harder, Callahan, Trevisan, & Brown, 2007).

A review of the recent literature on STEM educational research uncovers papers and studies predominantly within two areas. The need for directed attention to STEM due to a lack of future graduates (See for example Alkhasawneh & Hargraves, 2014; Williams, Kaui & Ernst, 2015) and retention studies to find out what support mechanisms can be employed within these subjects (Jackson, Charleston & Gilbert, 2014). There is little extant literature on the practicalities of *how* to deliver the content through effective and engaging methods.

One study of engineering students looked at the sequence of delivering content. In most scenarios, content is delivered first then applied to simulation exercises. In this study, the authors observed classes where the reverse was true (simulation followed by delivery of concepts) and found more engagement and deeper level of understanding of the content (Bowen & Deluca, 2015). As a result of student led enquiry (or student-centred learning) rather than teacher driven provision of content, the students are forced to investigate, observe, challenge and question before the concepts are given to reinforce the observation.

Transformational change in learning and teaching

Scientists have been described as 'naturally sceptical' though presenting them with research and data on student learning alone is seldom compelling enough to change their pedagogy (Wieman, Perkins & Gilbert, 2010). Studies have clearly shown that in courses taught with a traditional lecture format students are not assimilating many of the fundamental concepts of physics (Yoder & Cook, 2014). But since improving STEM undergraduate education is the aim, how does one entice STEM faculty to change? "Additional research evidence will play only a small role in this process" (Fairweather, 2008, p. 13). It is postulated that "a combination of easy to use adoption tools and a broad spectrum of adoption choices combined with convincing research" (Golter et al., 2012, p. 53) might be the answer.

There are many supplementary resources available for students including the traditional textbooks, lecturer's notes, lecturer's verbal descriptions, images, and 3D models. More recently, simulations, eBooks, animations and other open educational resources are easy to find on the Internet and through university libraries. But still we return to the question of how we can use such digital media to enhance the student experience. To provide a way for students to interact with the expert; to feel the passion and depth of knowledge a f2f experience can provide. Is a video interspersed with quiz questions to test understanding of concepts the answer?

Indeed, many lecturers are converting their (traditional) f2f lectures into recorded videos of various modality which can be placed in an online environment for ease of access by students. These same students may be expected to engage with these different forms of content before attending a f2f class where they will then use it for more active participation. This classic blend of online and f2f content is very good in theory but is it effective for students to master the content knowledge?

In conclusion, we do need to provide content for today's students in more contemporary formats but there are still many unanswered questions. What form does such digital media need to take, to be most effective? Who will create these artefacts? And will students engage with them?

Proposal

This discussion session intends to investigate how content is being delivered in these STEM disciplines as the uptake of active, collaborative and blended learning grows. By collecting a range of examples of good practice, a picture may emerge. Furthermore, how can digital media be used to deliver concepts in more effective and engaging ways?

Components	Science	Technology	Engineering	Mathematics
Video				
Video followed by quizzes				
eBooks with embedded quizzes				
Interactive online modules				

Table 1. Summary of practical methods for delivering content

A pre-conference Google document will be created and shared to conference participants through social media channels. Conference participants will be invited to collaborate and develop the number of examples during the conference, based on other presentations and sessions. In the allocated session time, questions can be raised, and descriptions clarified. Table 1 is an example of what this may look like, populated with a few scenarios.

In this way a practical toolkit of options can be made available for educational designers, developers and teaching academics to take back to their institutions for use and dissemination. These, coupled with a growing body of evidence may provide strong grounds to convince academics in the STEM disciplines to revisit the way they deliver content in their subjects.

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