The role of creativity in enhancing student learning in STEM subjects:

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Summary

This pamphlet aims to help academics incorporate more creative approaches to teaching and learning when designing modules for STEM subjects. This resource outlines the fundamental aspects of creativity, how to include these aspects in module design and delivery and how to appropriately assess creativity in the classroom.

What is creativity and why is it required in science teaching?

The demands being placed on Higher Education Institutes (HEI) are ever increasing, with the expectations of students in relation to the learning experience provided and the fundamental role of universities in training the next generation of critical thinkers. Because of this, it is important to consider the process of creative course design, delivery and assessment in producing graduates with the attributes, knowledge base and confidence to tackle any task (Donnelly and Fitzmaurice, 2005). Creativity is a difficult concept to define due to its complexity, with words such as originality, imagination, vision and innovation being associated with this term (DeHann, 2011; Hwang, 2017).

Common perceptions of creativity include an association with an individual having artistic prowess or producing an item of high aesthetic value (Gaut, 2010), while the academic community who specialise in creativity research suggest that creative attributes or outputs should include both unique and useful components (Beghetto, 2005). Creativity is represented by the tangible development of something new, in the Science, Technology, Engineering and Mathematical fields (STEM), this might be an idea, conceptual theory, methodology, patent, data set or paper. Alternatively, it can be described as the way in which we perceive particular problems and how we set about finding a solution to address them. However, many individuals working in the STEM fields often tend not to identify with the creative nature of their work, as the outputs described above represent a normal or expected outcome of their work. This is perhaps due to the perception of true creativity as being a major scientific breakthrough resulting in a complete paradigm shift in our understanding (DeHann, 2009). These types of “eureka” moments, described as Big-C or historical creativity where a difficult problem is solved through a flash of inspiration are rare, however little-c or psychological creativity is more widespread, where new ideas are generated by groups or individuals but are not new to the subject area (DeHann, 2009; Gaut, 2010).

The concept of little-c creativity can also be described as the “a-ha” moment for students, where the understanding of a topic or insight into solving a problem is attained (Herman et al. 2008). This is a multidimensional process which includes several stages such as the divergent phase where problems are visualised and ideas generated, the convergent phase where solutions are evaluated and the analytical phase, where new ideas are synthesised in relation to existing knowledge (DeHann, 2009).

Creativity is particularly important when we consider approaches to teaching and learning in higher education, which ideally will encourage higher level student engagement, enable active participation with the course material and will facilitate a deeper
understanding of the topic (Biggs, 1999). A useful approach to engage students in deep learning is constructive alignment, where expected learning outcomes are outlined in advance, and both the delivery of material and assessment techniques are tailored to engage the students and enable them to achieve the expected outcomes and higher order cognitive skills (HOCS) (Biggs, 2014).

How can we introduce creativity in module design and delivery?
In order to enhance the creative attributes of our students, it is necessary to embrace and include an element of chaos in the way in which they are taught (Gaut, 2010). However, the scientific process characteristically tends to function within a more constrained methodological framework, resulting in an output that is either right or wrong.

“Science is not just about a list of facts or having encyclopaedic knowledge; science, really, is about being wrong in interesting ways”
Professor Ian Dickie (2017).

The perspective of Professor Ian Dickie from the University of Canterbury, New Zealand which is detailed above, provides an important perspective on creativity in science, as the students need to have the flexibility, freedom and opportunity to be wrong in interesting ways, as this will help to develop non-routine problem solving skills (Dow and Mayer, 2004) and will help to consolidate their learning process through the development of HOCS. While the more traditional lecture-based teaching approaches, designed to facilitate the transmission of fundamental information, are an important part of scientific teaching (Handelsman et al. 2004), the development of HOCS skills can be encouraged in this forum by integrating active learning strategies into classes. Simple exercises such as think-pair-share-create encourage peer to peer engagement and help to develop divergent, convergent and analytical thinking skills, while only requiring a small proportion of the contact time (DeHann, 2011). Sternberg and Williams (2003) provide a range of useful tips for teaching creatively, these include acting as a creative role model when teaching, encouraging students to question assumptions and redefine problems, facilitating interdisciplinary exchange, allowing time for creative thinking and using assessment techniques that encourage and appropriately assess creativity.

How can we assess creativity?
In order to adequately assess creativity, we need once again to consider what creativity means, and to be able to distinguish the subtle differences between the utility, originality and significance of the creative nature of student assessments, particularly with regards to informative student feedback (Beghetto, 2005). From a student’s perspective it is also important to provide a suitable creativity framework to develop an understanding of what creativity is and what is required in this regard, so that they can reflect on their creative attributes and then progress in a creative manner (Brookhart, 2005; Mastracci, 2012). Without such guidance, the whole process of student evaluation and assessment can have a negative effect on creative expression and the development of HOCS due to the high volume of assessments on a particular course or programme, which limits the time available for the students to engage with the process and also the fundamental
pressure on an individual to produce something creative, especially if they are unsure about what this really means.

Wees (2012), provides several useful examples of formative assessment approaches that can enhance the creative attributes of students. These include writing subject summaries, hands-in-peer assessment, visualisation exercises, prediction and reasoning tasks, crowd-sourcing presentations for both input and feedback and metacognition assignments. These examples represent a varied array of assessment techniques and it is important to provide a coherent assessment rubric to assist both students and course facilitators in the development and assessment of creative assignments. A useful rubric for assessing creativity is provided by Brookhart (2013), which describes different levels of creativity ranging from imitative through to very creative and aligns these with the contextual importance of the content, the use of varied sources of information and original approaches to combining and communicating ideas.

**Examples of assessments that have inspired a creative response from the students**

Detailed below are a few examples of creative assignments that have been developed by senior sophister students on the Plant Science moderatorship who were asked to investigate the topic of plant communication.

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**Plants, herbivores and parasitoids: A story of love, betrayal and an unsuspecting hero.**

Simon Benson and Kerry Ryan created a puppet show (Figure 1) to describe plant morphological adaptations to herbivory and incorporated a video in their class presentation (https://tcd.cloud.panopto.eu/Panopto/Pages/Viewer.aspx?id=58316061-9589-4316-81d5-a85e00da65cc) to discuss the use of volatile organic compounds to communicate with parasitoid species when under biotic stress.

![Figure 1. Kerry Ryan and Simon Benson with their puppet show describing plant morphological adaptations to herbivory.](https://tcd.cloud.panopto.eu/Panopto/Pages/Viewer.aspx?id=58316061-9589-4316-81d5-a85e00da65cc)

**Crown Shyness.**

Rachel Phelan and Martin O’Neill created a conceptual model of a forest canopy using vegetables such as broccoli (Figure 2), to describe the concept of canopy shyness in forest ecosystems.

![Figure 2. Rachel Phelan and Martin O’Neill with their broccoli model of a forest canopy to illustrate the concept of canopy shyness.](https://tcd.cloud.panopto.eu/Panopto/Pages/Viewer.aspx?id=58316061-9589-4316-81d5-a85e00da65cc)
References


