Integrating ideas from design disciplines into the STEM curricula

The 'Future of Jobs' report from the World Economic Forum (2016) highlights that the three most important skills needed by the workforce from 2020 onwards are complex problem solving skills, critical thinking and creativity. To try and address the needs of the workforce, the report also recommends that higher educational institutions need to break away from "the dichotomy between Humanities and Sciences and applied and pure training" and to "work closely with governments, education providers and others to imagine what a true 21st century curriculum might look like."

One way of imagining what a 21st century STEM curriculum could look like is by taking inspiration from how design disciplines such as product design are taught and practiced. The product design curriculum is normally based on a product oriented learning strategy (Zhao, 2012) that integrates ideas from the humanities and sciences, mixing theory and practice. By having product focused projects and assessments within the curriculum, often in collaboration with industry, students are more likely to be intrinsically motivated, as one of the key factors supporting student engagement is the "perceived relevance of the learning task" (Kahu, Nelson & Picton, 2017). It also makes sure that the students are learning by being creators rather than by being passive consumers.

The product design curriculum has creativity at its heart. Creativity is about creating new ideas or artefacts (e.g. products) of value (Boden, 2004; Deininger, 2013). Three key factors affecting creativity are a person's skill levels, their 'state of being' and the process they follow (Csíkszentmihályi, 1996; Deininger, 2013). A creative process requires the exploration of many possible answers (divergent thinking) as well trying to find the best answer (convergent thinking) and is dynamic, non-linear and iterative in nature (Loudon and Deininger, 2014).

To create new ideas of value, product design students follow a creative process that requires them to gain inspiration by going out into the field and engaging with people they have not previously connected with, paying attention to what they have to say, what they do and what they use. Many of the techniques stem from anthropology (Kelley & Kelley, 2013). The product design curriculum is also structured to support multidisciplinary collaboration between students from different courses to bring in new ideas, perspectives and skills. Students are encouraged to explore new ideas, materials, technologies and concepts through play and experimentation and to evaluate ideas based on their desirability, viability and feasibility. One method used to help develop new ideas and concepts is through an iterative process of creating fast prototypes and testing them with key stakeholders. Such an approach combines theory and practice, and allows the exploration of a range of possible solutions without being too invested in any one solution.

Design teaching is undertaken in a studio environment rather than a lecture hall. The studio is flexible in its configuration and use, and enables group discussions and practical activities to take place as part of teaching sessions. It is also the students' home at the university, creating a sense of belonging (another key factor for student engagement). The social and physical environment affects a student's state of being and therefore it is important that there are areas to relax, focus, collaborate and have fun - positive emotion encourages engagement (Fredricksen, 2001). That is also one of the reasons why play and playfulness is important for idea generation and exploring new ideas. Fear of failure can be very harmful to creativity and engagement. To bring a sense of excitement and purpose together, 24-

hour commercial challenges are set for student teams by industry. Students also showcase all their work at the end of their studies in a final public exhibition. This provides a clear sense of purpose to the students' work and acts as a great recruitment opportunity for students and employers.

So how does this all relate to STEM education? Should ideas from the world of design be integrated into the STEM curricula? Swansea University have already been integrating some of these ideas into their courses for mechanical engineering and medical engineering (Harrison & Dorrington, 2018), as they wanted to increase their students' creativity and to help their students understand more deeply what needs they are trying to address and how to develop superior products. With class sizes of up to 200 students, they highlight that introducing a studio-based approach has been a challenge, however, they have managed this through running smaller group sessions split over a few weeks. Students are given product focused assessments and their sessions mix theory and practice. Students are encouraged to go out and to see how products are used in the real world to help develop clearer engineering design briefs. They are also taught ideation techniques and how to create fast prototypes to evaluate their new design ideas.

Perhaps more STEM courses could do the same? Perhaps more collaborative projects could be run with other courses. Maybe there could be more opportunities in STEM courses to learn through exploration, experimentation, play and through making mistakes. Perhaps creativity processes such as 'design thinking' (Kelley & Kelley, 2013) need to be taught. One consequence might be that student creativity, engagement and learning improves.

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