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Teaching creativity to undergraduate engineering students

Tim Dolmansley[1], Jevgenija Prisutova[1], Keith Tarnowski[1], Óscar Mascareñas[2]
[1]Department of Mechanical Engineering, University of Sheffield, United Kingdom,
[2]Irish World Academy Of Music & Dance, University of Limerick, Ireland.

Abstract

Over the recent years, it has become more and more apparent that creativity is a skill equally important for both technical and artistic careers. However, methods for teaching creativity that work for arts students are not always appropriate for engineering students. The present study outlines the adaptation of a creativity development session from an artistic degree curriculum (Mascareñas, 2019), to make it suitable for teaching to engineering students. The session was run three times with 1st and 2nd year engineering students at a Russell Group university in the north of England, and both qualitative and quantitative feedback was collected from students after the session. The main findings indicate the importance of a trusting relationship between students and the educator, the need for balance between delivering a memorable experience and offering support, and the significance of subsequent reflection.

Keywords: *engineering education; professional skills; creativity.*

1. Introduction

Creativity is one of the main differentiators between humans and animals (Csikszentmihalyi, 1996), and has a major impact on our lives, from arts to sciences. Innovation and creativity are in the top 5 of desired workplace skills for 2025 (World Economic Forum, 2020), and are crucial for a successful engineering career (Panthalookkaran, 2010).

Evolutionary changes to a technology or product make little market impact, but introduction of a new "disruptive" technology can completely change the market, leading to products that cannot be created through step-by-step improvements. An example of this is the sharp decline in Nokia mobile phone market share from 49.4% in 2007 to just 3% in 2013, after the introduction of the first iPhone in 2007 (Lee, 2013). It has been acknowledged that creativity is a crucial skill for an engineer, and effective strategies for developing creativity in engineers are needed (Zhou, 2012).

One of the main limitations on teaching creativity in an engineering context is the fact that engineering educators value creativity less than the final engineering product (Tekmen-Araci and Mann, 2019). Another difficulty in teaching creativity is the students' opinion of the topic, and the reluctance to step out of their comfort zone. Some typical blocks to creativity include fear of the unknown or of failure, frustration avoidance, reluctance to "play" or to let go, among others (Zhou, 2012). This discomfort of being creative is often coupled with a belief that creativity is a talent one is born with, rather than a skill that one can develop (Olken, 1964). This belief is inaccurate, and multiple authors have shown that creativity can be learnt and improves with practice (Pusca and Northwood, 2018; Tekmen-Araci and Mann, 2019). Different techniques have been tried by different authors, but most of them fall into four categories:

- **Support**: creativity requires risk taking and openness to uncertainty, for which students need support (Cropley and Cropley, 1998), including low-cost opportunities for failure, case studies, hands-on experience, and personal support.
- **Teaching creativity tools**: eg. brainstorming, mind mapping, morphological analysis, problem-based learning, idea checklists, and methods to allow creative ideas to surface (Zhou, 2012; Pusca and Northwood, 2018).
- **Experiencing creativity**: ensure students are well-prepared (they understand the problem through research and had time for incubation of ideas) (Guilford, 1950; Amabile, 1996) and provide a memorable creativity experience which is often not explicitly taught in science or engineering subjects (Sawyer, 2010).
- **Reflection**: review the creative processes and outcomes for future improvement (Guilford, 1950; Amabile, 1996).

Existing studies provide limited approaches to encourage creativity in engineering students, especially when it comes to experiencing creativity. The aim of this paper is to explore the development of exercises to teach creativity to engineering students by adapting methods from arts, originally proposed by Mascareñas (2019).

2. Methodology

The study presented in this paper reviews three years of implementation and evolution of a memorable creativity development session. The first session was run by the creator and author of the Class of Nothing method, Óscar Mascareñas, and the following two sessions were run by the module leader Tim Dolmansley. The general format described below has been used for all sessions but there have been significant changes and developments each year as lessons have been learnt, which are described in the Results and Discussion section. Each creativity development session consisted of four main sections:

Introduction. In the introduction session students were given information about creativity, its impact, and how creative solutions are developed. Research-based practical tools and methods to improve creativity were discussed.

The Class of Nothing. Students were invited into a room where there were no chairs or desks, and were initially given no instructions. Some objects were scattered around the room that were intended to promote creativity, eg. paper, scissors, felt tips, and similar. When the educator had sufficient attention from the students, the following 'rules' were read out and repeated several times:

"This class is about un-doing. Its purpose is not the destination, but who you become along the way. If you have any questions, don't ask (unless you know). I'm not here to answer questions – like you, I'm here to formulate them and try them out. To take part in it, all you need is to be present. Carefully and continuously listen and observe. Awareness is key. Be patient and have no expectations. Contribute if you wish. Communicate, but do not speak (unless it is about nothing). Don't waste time. Nothing is the space of infinite possibilities."

The educator then proceeded with an arbitrary creative task, eg. making origami, and left the students to decide for themselves what to do. It is usual to have an awkward pause (often 15 minutes), followed by an explosion of energy and creativity.

Practical methods. Students had been taught methods to improve creativity, and were given time to practise them. The practical methods included traditional and silent brainstorming, walking, and sorting Lego bricks into colours. This should preferably be related to the specific project students are working on, and carried out in project teams.

Reflection. Students were asked to reflect on their experience in a live lecture to increase participation and promote discussions. The information was gathered through multiple choice and open-ended questions.

The creativity development session was taught as a part of a design module to 1st and 2nd year mechanical, bio- and aerospace engineering students in a Russell Group university in the north of England. The detailed information about each cohort is presented in Table 1.

Table 1. Student cohort details. Mech – Mechanical Engineering; Bio – Bioengineering; Aero – Aerospace Engineering.

Cohort no.	Student group	Cohort size	No. of respondents	Debrief and questionnaire after the Class of Nothing
1	1st year Mech and Bio	205	26	Same day
2	2nd year Mech and Aero	190	106	1 week
			12	1 year
3	1st year Mech	200	90	1 day

3. Results and discussion

3.1. Cohort 1

Cohort 1 had the creativity development session delivered by Óscar Mascareñas, the author of the Class of Nothing method (Mascareñas, 2019). It consisted of a one-hour lecture to introduce creativity, delivered in an unusual, performative style, a half-an-hour creativity exercise workshop, a one-hour Class of Nothing section, and a debrief session. The post-session questionnaire was administered in the debrief section, following the Class of Nothing. The results of the multiple-choice questions are presented in Figure 1.

When asked about the effectiveness of the Class of Nothing through a show of hands in a debrief session, it was found that the class was very successful for the majority of students (85%). Approximately 15% left the class during the 15 minutes of tension, and were very vocally negative towards the class. Through the show of hands it was established that it was mostly these students who responded to the questionnaire, as shown in Figure 1. The negative feedback was further exemplified in responses to an open-ended question, "Do you have any suggestions for running this next year?" The responses ranged between suggesting a gentler introduction to the session, eg. *"prepare everyone before so less people leave when it's not what they expected"*, to urging not to run it the following year, eg. *"it was completely irrelevant and unhelpful in relation to our instrument designs"* and *"the class of nothing felt a bit pointless, so replace that with other creative techniques*

teaching". However, these students were still discussing the class with the module leader or personal tutors a year later, by which time they had processed the experience and had learnt about creativity through personal reflection, achieving the same as had they experienced the class.

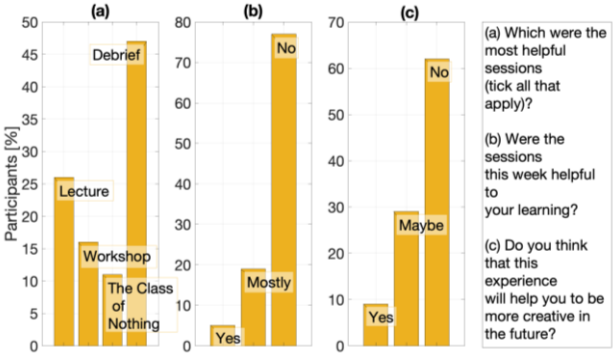

Figure 1. Cohort 1 responses to the post-session questionnaire, immediately after the session.

The timing of the session was unfortunate, as it was scheduled before an exam later in the day, which made it more difficult for students to commit to the session. Furthermore, students needed to feel that creativity was more credible and needed more support. Therefore, better care of timing, preparation and time to build a trusting relationship with the educator was important.

3.2. Cohort 2

After reflecting on the experience, the creativity development session for Cohort 2 was fully delivered by the module leader, Tim Dolmansley. The information lecture was also adapted to include more of the science behind creativity, as well as some practical methods students could use. The Class of Nothing was delivered after the information lecture and a practical workshop followed the Class of Nothing to focus the creativity on the specific design task. A debrief session took place one week after the Class of Nothing, where students were asked some open-ended questions about the creativity development session. Students were asked to say something negative about the session, and their answers could be attributed to the following broad categories: (i) the bizzareness and the lack of direction in the Class of Nothing, eg. *"at the beginning of the session, nobody had a clue what was going on. It was very uncomfortable and there were people considering leaving"*; (ii) reluctance to follow creativity exercises, eg. *"felt like an idiot walking around with a plant pot and feather"* and *"didn't help me generate any ideas. would have been better off having more FEA* (Finite Element Modelling) *sessions … I didn't brainstorm any better for the class."*; (iii) timing concerns, eg. *"each activity ran for slightly too long… slightly too long overall session time as well"*; and (iv) inability to take part in exercises due to team

members missing. The positives focused on (i) unusual experience, eg. *"I really enjoyed brainstorming in different ways, such as the walking and talking and not speaking activities. It was interesting to see how much difference it made"*; (ii) improved creativity, eg. *"it allowed different brainstorming methods to usual and that led to different and novel ideas"* and *"helped me understand how the brain works creatively and how to enable it"*; and (iii) team bonding. When students were contacted one year after the creativity development session, most of the students who responded (68%) said that the lecture on the science of creativity helped them to make the most of the Class of Nothing (see Figure 2).

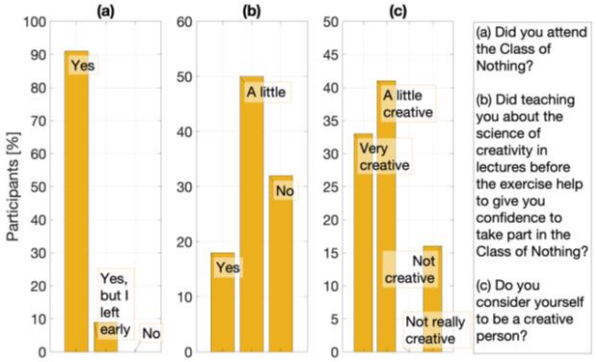

Figure 2. Cohort 2 responses to the post-session questionnaire, one year after the session.

74% of the students stated that they consider themselves creative to some degree. The technical explanation of the validity of the creativity exercises led to more positive feedback from Cohort 2. However, it was observed from the gathered data that students who were previously taught by the educator reported higher benefits from the session. This leads to a conclusion that the relationship between the students and the educator needs to be more established for the creativity development session to be successful.

3.3 Cohort 3

Cohort 3 also had their creativity development session fully delivered by Tim Dolmansley. Its format was the same as that of the session delivered to Cohort 2, with some further improvements made. The session was delivered later in the term (Week 9, as opposed to Week 4 for Cohort 2), which meant that the students had more time to get to know the educator and their peers, and develop a relationship with them. In addition, the students were more settled and independent by this point of the term, which enabled them to be better academically and emotionally prepared.

When asked to say something negative about the creativity development session, Cohort 3 students had very similar feedback to that of Cohort 2, highlighting the lack of instruction and structure, lack of engagement from peers, and struggling to see benefits of the exercise.

Some students also noted that the Class of Nothing could have turned unsafe, and others voiced concerns about suitability and benefits of the class for some groups, eg. introverts or people experiencing anxiety. Positive feedback included statements that the class was *"fun"*, *"relaxed"*, *"different"*, and gave students creative freedom. Students also remarked on the benefits for their creative skill development, eg. *"nothingness forced creative juices to flow"*, as well as impact on their communication skills, eg. *"different interactions with peers"*. The responses to multiple-choice questions shown in Figure 3 point to a significantly more positive feedback. 97% of students found the lecture on the science of creativity useful to some degree, out of which 44% found it very useful, and 97% of students found the Class of Nothing useful (35% of them – very useful).

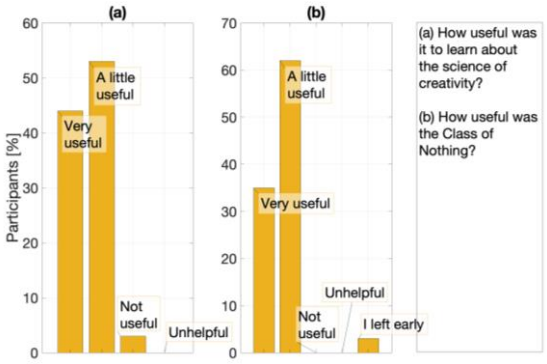

Figure 3. Cohort 3 responses to the post-session questionnaire, one week after the session.

4. Conclusions

This study focused on a creativity development exercise which combined a session on the science of creativity and practical tools with a memorable creative experience, where the latter is usually overlooked in teaching creativity for engineering students. It resulted in the following three main findings. Firstly, the correct timing of the creativity development session is important. It was shown through the gathered feedback that when students did not know the educator well, they reported lower benefits of the creativity development session, at least in the short term. Students should be given sufficient time to build relationships with their educator and peers to make the most benefit of this exercise, as they need to have trust in the educator to follow them through such an unstructured and potentially confusing session. The scheduling of the session is important as well, as it is best to avoid placing it before an important assessment or later in the day when students are more tired. Secondly, it is crucial to give students the right balance of powerful experience and support in this exercise. On one hand, the experience has to be memorable to have a long-term impact on students' creativity skills. On the other hand, there is a need for well-trained staff who can

identify those students who need support and provide it. Furthermore, students with specific needs have to be carefully considered, and it should be made clear to students that there is no obligation to take part in the exercise. Finally, a reflective debrief after the Class of Nothing is crucial to reinforce learning benefits. Students might have mixed feelings after the unusual session, and it is important to give them space to discuss it. Some students might also need support overcoming any anxiety from the session.

References

Amabile, T.M. (1996). *Creativity and Innovation in Organizations*. Harvard Business School Background Note 396-239, January 1996.

Cropley, D. H. & Cropley, A. J. (1998). Teaching engineering students to be creative - program and outcomes. *Proceedings of the Australasian Association of Engineering Education (AAEE) 1998*.

Csikszentmihalyi, M. (1996). *Creativity: Flow and the Psychology of Discovery and Invention*. New York: Harper Collins.

Guilford, J. P. (1950). Creativity. *American Psychologist*, 5(9), 444–454. doi:10.1037/h0063487

Lee, D. (2013). *Nokia: The rise and fall of a mobile giant*. BBC. Retrieved January 20, 2022, from https://www.bbc.co.uk/news/technology-23947212 .

Mascareñas, Ó. (2019). A Class of Nothing. *Proceedings of the 5th International Conference on Higher Education Advances (HEAd 2019)*, Valencia, Spain, 2019.

Olken, H. (1964). Creativity Training for Engineers - Its Past, Present, and Future. *IEEE Transactions on Education*, E-7(4), 149-161., doi:10.1109/TE.1964.4321869

Panthalookkaran, V. (2010). Hour of creativity: an agenda to foster creativity and innovation in the students of engineering. *Proceedings of 2011 IEEE Global Engineering Conference (EDUCON)- "Learning Environments and Ecosystems in Engineering Education"*, 612-617. doi:10.1109/EDUCON.2011.5773201

Pusca, D. & Northwood, D. (2019). Curiosity, creativity and engineering education. *Global Journal of Engineering Education*, 20(3), 152-158.

Sawyer, R. K. (2010). *Learning for creativity*. In R. A. Beghetto & J. C. Kaufman (Eds.), Nurturing creativity in the classroom (pp. 172–190). Cambridge University Press. doi:10.1017/CBO9780511781629.009

Tekmen-Araci, Y., & Mann, L. (2019). Instructor approaches to creativity in engineering design education. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, 233(2), 395–402. doi:10.1177/0954406218758795

World Economic Forum (2020). *Future of Jobs Report*. Retrieved from http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf.

Zhou, C. (2012). Teaching engineering students creativity: A review of applied strategies. *Journal on Efficiency and Responsibility in Education and Science*, 5(2), 99-114. doi: 10.7160/eriesj.2012.050205