

DESIGN AND ENGINEERING PEDAGOGIES AS AGENTS FOR DISRUPTION, INNOVATION AND TRANSFORMATION AND THE TRANSFER AND APPLICATION OF REVERSE PSYCHOLOGY ACROSS DISCIPLINES

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ABSTRACT

Design and engineering have individually and collectively disrupted and transformed societies, economies and the environment through innovative and regenerative practice and activities. Design and engineering education have also been transformative especially the former to which experiential, active, problem and project-based learning has always been central. This paper considers an innovative and particular teaching method – reverse psychology – that employs disruptive thinking and is being used to teach design and engineering students about sustainability. The project, results and impact are discussed in detail and were presented at EPDE21 [1]. The method proved highly successful and feedback suggested that it could be applicable to participants other than university students. This paper describes the subsequent research and its relevance to design and engineering education. The theory was tested in a workshop at an academic staff conference. Feedback was again very positive and a further workshop for academics from different disciplines was organised to develop subject-specific material and assess whether the method was transferable across disciplines. The experience proved highly beneficial to all parties who learnt from each other; the bespoke materials developed during the session were subsequently tested with students who again responded very positively, which soundly endorsed transferability. These various results show that design education remains innovative and is leading and supporting development of pioneering educational practices. Furthermore the design and engineering academics involved in the research learned from colleagues in other disciplines which supports and illustrates the benefit of transdisciplinary collaboration.

Keywords: Reverse psychology, disruptive thinking, deep learning

1 SIMILARITIES AND DIFFERENCES IN DESIGN AND ENGINEERING EDUCATION

1.1 The origins of design and engineering education

Engineering has been practiced for thousands of years although ‘modern’ engineering and the engineering profession began with the first and second Industrial Revolutions in the 18th century; the profession has continued to evolve and to push and pull development of the third and fourth Industrial Revolutions and technologies. Design has also been practiced for thousands of years as an activity in its own right and as part of the engineering process and more formal practice also emerged and evolved from the first and second Industrial revolutions. Although it was initially practiced by architects, craftspeople and engineers, the introduction of new technologies, materials and manufacturing processes encouraged development of more independent design practice and profession, which have also progressed continually and responded to and initiated technological development and change.

The various technical and economic changes associated with engineering, design and society as a whole necessitated the establishment of specialist training and education provision. For example the Royal Society for the Encouragement of Arts, Manufactures and Commerce (RSA) was founded in 1754 to ensure good links between the arts, manufacturing and society, as a result of which an associated school

was set up in 1762. Subsequently in 1836 the first design (Normal) schools were founded near to manufacturing centres and in addition to preparing individuals from employment, their mission was to development of 'good' design. In 1824 the first engineering college was also founded in Manchester to prepare local working men for employment in industry by training them in the principles of science. The sector subsequently evolved and diversified and in 1920, the Borough Polytechnic Institute (now London South Bank University) became the first institution to admit female students to engineering courses.

1.2 Design education and methods as exemplars of good practice

Although design and engineering education share similar histories, there were and are some significant differences in the approach to teaching and learning. For example, traditional engineering education employed and employs passive (lecture-lab) learning methods and subjects were and are compartmentalised. Conversely, design education has always focussed on experiential and active learning, which goes hand-in-hand with problem-based and project-based learning (PBL). Although the former tends towards discovery of knowledge and the latter to focus on the application of knowledge, [2, 3], both are well-established learning methods that have been shown to increase engagement, the outcome of which is higher marks [4, 5]. By demonstrating the value of experiential learning, design education has served as an exemplar and adoption of this approach to teaching and learning across disciplines including engineering is increasing.

Design Thinking is another example of innovative practice that has been embraced by other disciplines. Although it has always been integral to the design process and profession, it was not formalised and widely publicised until 2005 by the UK Design Council, who subsequently expanded it and promoted it as a framework for innovation in 2015. Design Thinking was also publicised by Tim Brown and IDEO who actively promoted the approach as an aid to creative problem solving to business in general. This methodology has proved very successful across disciplines and professions and consequently a number of high profile educational institutions are running Design Thinking courses that are open to participants from any discipline. There are numerous publications that describe the impact and success of Design Thinking in a wide range of sectors including FMCG, commerce, non-profit/NGOs, healthcare, transport, education, finance and self-improvement, which confirms the transferability of another design-based methodology to other disciplines.

1.3 Encouraging innovation in engineering education

Although engineering education is evolving there is still scope to learn from design education. For example a 2017 report Royal Academy of Engineering report [6] proposed that engineers should be encouraged to be open, personable, and able to (sometimes) dispense with tradition in order to address the challenges of the future. Similarly a 2018 report jointly produced by UCL Centre for Engineering Education and Lloyd's Register [7] proposed that engineering needs to adopt practices that are already inherent to design: "the new roles engineers are forging need reimagined imagery that highlights them creating, innovating, designing and using technologies, working together in teams, being in a variety of settings and working across disciplinary and cultural borders". Overall, then future education in engineering should break down barriers, and encourage a culture of openness and diverse thinking, which are inherent to design education.

In response to the need to encourage a break with tradition and promote diverse thinking among engineering students as well as the need to address changing environmental and social factors among engineering and design students, academics at London South Bank University developed a project that disrupts conventional approaches to teaching and learning as follows.

2 DISRUPTION AS AN AID TO DEEP LEARNING AND EDUCATION FOR SUSTAINABILITY FOR DESIGN AND ENGINEERING STUDENTS

Students, young people, and society in general are currently facing many unforeseen challenges, and there has been a significant increase in reported mental health incidents. This is partly due to increasing service provision, and acknowledgment of mental health problems (the most common of which are depression and anxiety) and also to social and environmental changes. Triggers are complex and vary and may be associated with personal relationships or more general phenomena such as climate change, which is directly linked to conditions such as eco-anxiety, eco-apathy and climate depression. As educators it is our responsibility to support students' health and wellbeing and the 'Being Bad to do

Good' design assignment was developed to simultaneously teach first year Product Design (PD) and Engineering Product Design (EPD) students about sustainability and the UN Sustainable Development Goals while helping them to address negative feelings about the climate and environment and to foster empowerment. The assignment was also a catalyst to encourage students from technical and engineering (as opposed to pure) design backgrounds to engage in untraditional, exploratory, interdisciplinary project-based learning. The assignment was introduced in 2018 and has run annually since then. The assignment employed reverse psychology and disrupted common pedagogic practice in that students were asked to develop the most unsustainable solutions to a series of themes including resource use, water, food, energy. The approach proved very effective and all students who took part not only enjoyed the experience but qualitative research also revealed that they believed that they learnt more than they would have learned from a more conventional assignment. Further analysis of design output revealed that that generation of more innovative design proposals and quantitative research also resulted in an upward trend and marks for this and for subsequent higher-level sustainability-related design assignments. This is because 'Being Bad' encourages students to consider challenges in unexpected ways, to engage in deeper learning and retention of information [8]. It is also 'fun' and enjoyment also increases learning and retention of information. This research is on-going and the project, methodology and results at various stages have been presented and acclaimed at the 2020 Life Cycle Innovation conference, the Forum for Sustainability through Life Cycle Innovation and most recently the 23rd International Conference on Engineering and Product Design Education [1].

The widespread interest in and enthusiastic response to the project from experts working in diverse disciplines and the fact that the design profession and education have an established track record of innovation and sharing good practice provoked the question: like experiential / project based learning and Design Thinking can this particular design and engineering pedagogy - reverse psychology – also be successfully transferred to other disciplines to help educators to improve content delivery and improve student learning and experience?

3 TRANSFER OF A DESIGN AND ENGINEERING PEDAGOGY

3.1 Testing the concept and improving teaching in general

Although the response to the concept from individuals working in different disciplines was very positive, no-one other than PD and EPD students had personal experience of the methodology. In order to evaluate the direct impact on individuals working in other disciplines, and the transferability of the overall concept to another subject it was tested at Staff Teaching and Learning Conference. In this case rather than encouraging staff to share ideas about *good* teaching, they were asked to design a *bad* lecture. The audience participation was recorded over twenty minutes, and a summary of bad teaching, grouped around five themes, was produced. The themes were (a) Teaching Content (which included example responses from staff such as putting the difficult material first and the conceptual underpinnings later); (b) Environment (not enough seating, hot or cold rooms); Classroom Dynamics (uncontrolled talkative students; abuse of web tools); IT (inability of staff to connect to systems; networks don't work); (d) Teaching delivery (no checks on learning or feedback; telling the students that a third of them won't be there next year).

The exercise enabled staff to categorise some of the ways this reverse psychology can be liberating in the classroom. Some responses hint at the catharsis of being able to voice frustrations ("freezing cold lecture halls," "networks don't work.") Some responses are creative and funny ("been lecturing to the wrong students altogether"). Some act as a gentle reminder of serious problems that academic staff need to address and manage ("students bullying and harassing each other"), and some identify small mistakes that staff can all make repeatedly ("being on mute".) There are many different ways to do things badly, and each of them can help academics identify ways to do things well.

The session was one of the most popular at the conference and was highlighted in the conference closing address as an example of innovative educational practice. It was attended by over 30 delegates, seven of whom filled in an optional feedback form. Levels of audience participation (via MS Teams) were high within the session, and discussion covered a range of experiences from teaching staff, administrative staff and senior management. Written feedback was widely positive: six of seven respondents said it had made them think differently about their teaching; five said they would now incorporate the technique into their teaching; and all seven respondents asked to take part in discipline-specific workshops for their specific fields, and as a result, a further workshop was organised.

3.2 The impact of the concept on students in different disciplines

Using reverse psychology to inform teaching practice had proved very successful with PD and EPD Design students and so it was desirable to determine if this methodology could be effective for other subjects. To introduce the practice, teaching staff from various disciplines were invited to attend a workshop where an overview was presented, after which they had the opportunity to work on subject-specific topics to present to their students. This session was attended by delegates from Construction Law, Psychology, The Bakery School (including food science and nutrition) and Information Technology.

The delegates were fascinated by the innovative reverse psychology approach and it is worth reporting some of the comments that they made as they developed their own teaching sessions. It was agreed that this sort of activity lends itself to co-creation, a practice whereby students are active participants, interacting and working collaboratively with academics to co-create their learning space. Co-creation practice has been found to nurture student engagement and motivation [9]. It is important not to be too rigid but the method allows students to learn/achieve in a fun way. Another issue for educators is to ensure that the whole class has input, not just those brave enough to speak out. One person described the method as being a good way to help young people deal with performance anxiety by reducing the fear of being wrong. For students who are worried about being wrong, if the aim of the task is to 'fail' then they may think, "*OK I can do this.*" Fear of failure is something that holds back students from fully engaging with their studies, although failure has been shown to be a positive strategy if there is thoughtful feedback. Unlike other teaching methods this method actively encourages failure. One delegate pointed out that they "*liked the fact that it may help weakest students who are afraid of putting their hand up.*" They also pointed out that it was a way of teaching students to think.

A delegate from Psychology pointed out that there is a need for the tutor to exercise caution; not all topics would be suitable for this approach, especially sensitive subjects surrounding issues like mental health. Nevertheless we argue that this is a great methodology as it is fresh and new for the student; if it were used for all classes however, students would quickly become inured to it and it would lose its appeal. At the end of the workshop, delegates were asked to give feedback on the session. In answer to the question 'why did you join the workshop?', responses focused on a desire to raise student engagement, making sessions more fun and personal development. There was a desire to learn new techniques for teaching, creative lecture development and to "*do things better.*" Everyone reported that they had gained what they had hoped, and more, citing how refreshing it was to have a session like this to be able to meet and talk openly with colleagues from other disciplines. Everyone reported that they found the session really helpful and intended to include this methodology in their teaching in the future. Although all of the delegates stated that they were keen to try this approach some are still developing ideas for modules which are not running yet. To date the method has been used by academics in Psychology and Law. In a Psychology MSc course on research methods, students were given a completed ethics form to critique. The ethics form had been created by the tutor with many flaws, ranging from design errors, ethical debates, things sometimes not considered, and some points that should be immediately obvious. The students were mainly from a professional background with little research experience and therefore this is a challenging, but important, topic. The tutor reported that both the students and the seminar leader enjoyed the session giving unprompted feedback that it had been both enjoyable and informative. This is important because as motivated tutor will get more student engagement.

Psychology also used this for some sessions with second year undergraduate students, specifically to introduce a key hypothesis in cognition to the students. In this case they were asked to design a study to investigate a specific area of cognition but it had to break as many of the British Psychological Society's codes of ethics as possible. They worked in groups and then presented their ideas to each other. A follow up session asked them to adapt their ideas to make the study ethical but to consider the difficulties that also presented to what they were able to do. This was followed by a survey to get feedback (one for the students and one for the tutors) with the results reported in Table 1:

Table 1. Survey responses from students and staff

Questions to students	Definite Yes	Probable Yes	Neutral	Probable No	Definite No
Did you enjoy the activity more than if you had been asked to just design a study?	31%	45%	7%	17%	-
Did you think that this way of thinking deepened your understanding of ethics and their importance?	29%	45%	7%	17%	2%
Did you think that this way of thinking deepened your understanding of a difficult topic?	17%	43%	26%	14%	-
Questions to staff					
Did you enjoy the activity more than if you had been asked to just guide designing a study?	71%	29%	-	-	-
Do you think the students enjoyed this as a seminar activity?	29%	43%	14%	14%	-
Did you think that this way of thinking deepened the student's understanding of a difficult topic?	57%	43%	-	-	-

4 CONCLUSIONS

In conclusion, in design education there are already excellent well-established examples of innovation and leadership of good practice (including experiential and project-based / active learning) that have been adopted and practiced in other disciplines including engineering; similarly the design profession has generated excellent examples of approaches to and methods for innovation and problem solving (specifically design thinking) that are being employed across different disciplines and professions. These exemplars inspired the authors of this paper to ascertain whether a novel pedagogy they developed and that had proved successful on design and engineering courses could be transferred to other disciplines in order to support educators and benefit students. This paper briefly describes an assignment - 'Being Bad to do Good' – that disrupts conventional pedagogies by asking students to design *unsustainable* rather than *sustainable* solutions to problems. The assignment uses reverse psychology, which was found to enhance engagement, retention and deep learning by demanding unconventional thought and making learning 'fun.'

The method appeared to be suitable for transfer to other disciplines and consequently the concept was first tested with academic staff in a conference workshop. In this case reverse psychology was used to improve teaching by encouraging participants to consider and raise awareness of bad practice. Interestingly the initial response of the academic staff was the same as that of the PD and EPD students in that they didn't believe that they were being asked to do something 'bad' rather than 'good'. However once reassured, participation and engagement was high, the workshop was lively and enjoyable, and the positive results indicated that the concept was relevant and applicable across disciplines. A further reverse psychology workshop that focussed on developing bespoke materials for different subjects and subsequent sessions with students also confirmed that the method can be successfully transferred across disciplines, all of which highlights the potential for application in other business and professional fields. Although the 'bespoke subjects' workshop began with an overview of reverse psychology and its application in design and engineering, the session became a valuable mutually beneficial dialogue to which all parties were contributing and learning from each other. This qualitative evidence indicates that the approach also helped to break down interdisciplinary barriers. We conclude that use of reverse

psychology has been shown to benefit students and academic staff and to demonstrate the successful transfer of a disruptive design and engineering pedagogy to other disciplines; it has also shown that transdisciplinary interaction is beneficial to all parties and should be encouraged and facilitated in academic institutions.

Finally, this series of academic staff workshops and student activities demonstrate that design and engineering education continue to lead innovation and good practice across disciplines and that 'disruption' can create positive transformation if carefully planned and appropriate. Research into the use of reverse psychology is on-going via collaboration with academics from different design, engineering and other subject areas (including Law and the National Bakery School) and the various results will be analysed and compared to learn whether the method is more successful in some disciplines, subjects and assignments than others. The success of the concept has inspired the originators to continue to explore further innovative teaching practice in design and engineering education and beyond.

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