INNOVATIVE TEACHING METHODS FOR TRANSFORMATIVE SKILLS IN HIGHER EDUCATION ENGINEERING PROGRAMMES – A REVIEW

Inam Ul Ahad[1,*] , Muhannad Ahmed Obeidi[1], David Culliton[2], and Dermot Brabazon[1]

School of Mechanical and Manufacturing Engineering, Dublin City University, Dublin, Ireland
Faculty of Engineering, South East Technological University, Carlow, Ireland

Abstract: Transformative skills are becoming critical requirement in the job advertisements for engineering graduates. Transformative skills help engineers to identify, critically analyse and solve the challenges with engineering techniques and knowledge. Graduate level engineering programmes offer separate modules consisting of transformative skills such as project and innovation management, research methodology and communication skills etc. However, there is a growing interest and developments in integrating elements of transformative skills throughout the engineering programme modules so that students can develop competencies to meet the requirements of industry. The three major transformative competencies identified by Organisation for Economic Co-operation and Development (OECD) Learning Compass 2030 include new value creation, reconciling tensions and dilemmas and taking responsibility. This paper represents some critical teaching and assessment methods that can induce transformative skills in the students throughout their learning experience during engineering graduate programmes. Innovative teaching methods currently being used in engineering programmes include development of business and impact canvas, blog writing, self evaluation and peer review. These transformative skills elements can be easily integrated into several technical modules and offer enhanced learning experience and increased employability of graduates.

Keywords: symposium, engineering education, transformation, unsustainable, society, international.

Correspondence to: I. U. Ahad, School of Mechanical and Manufacturing Engineering, Dublin City University, Ireland. E-mail: inamul.ahad@dcu.ie

1. INTRODUCTION

The engineering programmes in higher education are designed to provide a comprehensive skillset in a specific engineering field to produce a workforce necessary to run the engineering and related service industries. Although the core topics in engineering programmes are focused on introducing fundamental and advanced technical concepts, soft skills based modules are always part of these programmes, equipping students will skills that are necessary in all engineering and non-engineering professions (Miranda *et al.*, 2021). These non-technical modules develop communication, management, risk management, decision making, team work, ethics, and other core skills that are required for proper functioning of any business. The graduate engineers with

combination of these skills are able to critically analyse the problems and retain their value as innovators and leaders, the high demanding qualities required by the engineering industry.

The term "transversal skills" is often used for soft skills which are not related to any specific discipline, rather these are skills are necessary for working in any field as they correspond to the behaviour of the worker in any occupation. Transversal skills are essential part of academic programmes worldwide. However, due to fast pace development and introduction of new and innovative technologies and the changes fourth industrial revolution and Industry 4.0 technologies are bringing, "transformative skills" are required in engineers to remain competitive for employability. Transformative skills in engineers are driving the innovation and value addition in the new and innovative products and services. Learning Compass 2030 is developed by Organisation for Economic Co-operation and Development (OECD) as a learning framework which can be used to enhance current and develop future educational programmes according to the needs of 21st century. The Learning Compass 2030 has categorised the transformative competencies in three groups, namely new value creation, reconciling tensions and dilemmas and taking responsibility.

Teaching transformative skills in addition to academic modules, in well defined and well structured engineering programmes is challenging for the teachers. The use of innovative techniques for teaching and assessment allows the lecturers to deliver the required technical teaching contents while introducing transformative skills via assessments and group activities. The use of Information Technology (IT) make it easy to develop and utilise electronic learning (e-learning) tools for introducing the transformative skills while making assessments for technical modules (Luo et. al 2020). In addition to successful introduction of transformative skills, students experience an enhanced learning experience and teachers are able to engage students to a very high level (Karkoub and Abdulla, 2020).

This paper presents a review of increasingly popular methods used for introducing transformative skills in higher education engineering programmes. Figure 1 illustrates the major skills and traits of transformational leaders. These qualities can be introduced in the engineering students with a combination of innovative teaching and assessment methods while delivering the required technical contents of an engineering programme. Adoption of an innovative teaching method could result in several transformational skills and attributes in engineers. Business and Impact Planning Model Canvas (Suranto and Nurlaela, 2021), (Silla, 2021), Self and Peer Assessment via pre-defined rubric (Van Hattum-Janssen *et al.*, 2021), and Blog Writing (Yildiz Durak, 2022) are few examples of teaching methods used in engineering programmes for transformational skills.

Figure 1 Major skills and traits of transformational leaders

2. TRANSFORMING SKILLS IN HIGHER EDUCATION

2.1 Business Canvas Model

Business Canvas Model (BCM), also termed as Business Model Canvas (BMC) is a common method used in business education for designing and analysis of a business idea or a new business activity in a company. For any business to start, a comprehensive business plan is essential. Lack of carefully drafted business plan is the major reason behind failure of start-ups, enterprises and business ideas as proper research work is not performed to examine the market conditions. While preparing a business plan is time consuming job, demanding several months of research and planning activities and writing, a Business Canvas Model provides a great instrument that can be used to develop and analyse a business model in a structured way, mostly within a few hours. BCM allows to identify and list several key features of a business structure and provides a visual model to state value proposition with clear value chain and financial prospects. Figure 2 illustrates the structure and main elements of a BCM, covering all strategic features need to be identified for a successful business. Within the already structured and approved engineering modules, BCM can be easily implemented. As the engineering modules often include case study type assessment, in which the students are asked to prepare a case study on a particular technology, often introduction of an innovative solution to address a critical challenge in the industry. Instead of a detailed case study report, lectures are now using BCM as assessment tool for engineering students. Although the students spend same amount of time, the structured formation of BCM provides students a great tool to develop a strategic model for introducing a new product or service in the market.

BCM introduces entrepreneurial skills which are critically important for the future talent work force of any economy, as they help to create new jobs, products and services (Moraes *et al.*, 2019; Suranto and Nurlaela, 2021). Hutasuhut et al. (2020) investigated the difference between the students' entrepreneurial learning skills achievements with and without the use of Business Model Canvas (BMC). It was reported that students with BMC experience showed 12.52% higher entrepreneurial learning skills comparing to the control group class. It was demonstrated that students who gained entrepreneurial skills via BMC have more entrepreneurial intentions (6.15% higher) (Hutasuhut *et al.*, 2020).
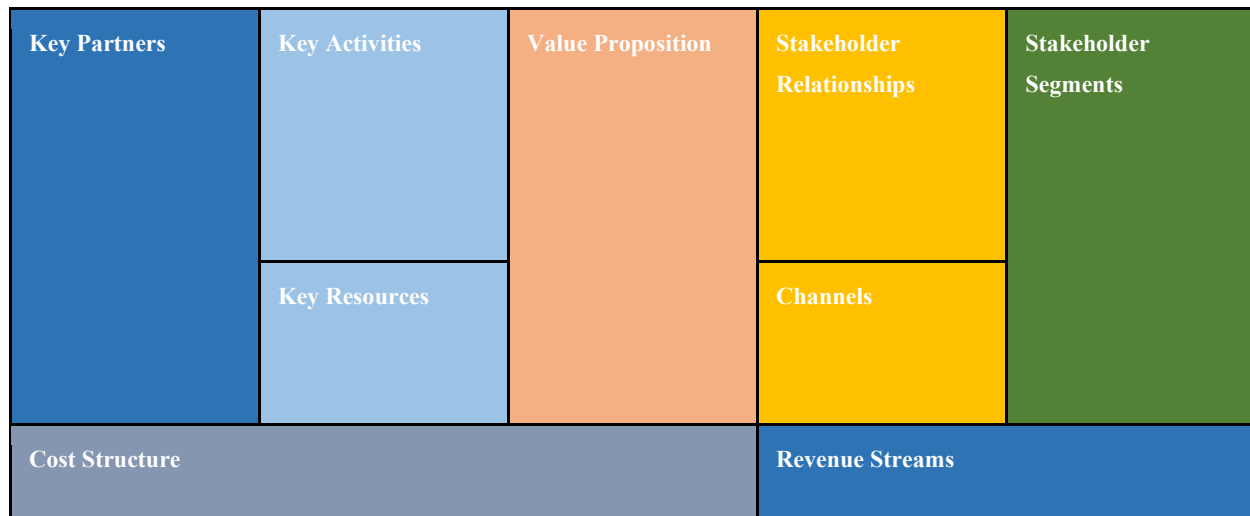
Key Partners	Key Activities	Value Proposition	Stakeholder Relationships	Stakeholder Segments
	Key Resources		Channels	
Cost Structure			Revenue Streams	

Figure 2 Business Canvas Model structure with essential elements

2.2 Self Evaluation

Self evaluation and awareness is a key quality which is essential for self development and progress in career. This quality allows the engineers to monitor and evaluate their competencies, knowledge, strengths and weaknesses and identify baseline to set up their goals. In fact, enterprises all over the world are determining performance evaluation on the basis of self assessment. Hence, for setting up future goals and examine the progress made, self evaluation drives the motivation and facilitates person in professional development and progress in the real world. For engineers, like other trades, self-management and organisation is vital to achieve success. The outcome of self assessment is quality assurance, which motivates the students for active participation in learning activities, improve their education and skills, consequently improving the performance. In engineering education, self evaluation skillset are required as a number of modules have group projects, in which individuals' contributions and progress need to be monitored. Although the group projects have a number of benefits, as students usually attain deeper learning and retain information for longer durations (Kommula et. al 2010). However, it is important for students to become aware about their individual learnings from the group projects. Self assessment in group projects or where a person is working in a team triggers self management and organisation skills while working in a team or under minimal supervision. Lynch (2018) performed two experiments to examine students' consciousness and confident level on their competencies in engineering and non-engineering subjects. The students who were given marking rubric on the basis of which the assessments were made, were more consciously competent (80%) comparing to those who did not receive grading rubric (50.3%). This study showed that once a structured self-assessment tool was

given, the students were able to consciously determine their competence level. Knowledge Surveys (KS) are often useful as they provide structured self-assessment tool where emphasise is on the level of confidence about knowledge in a subject, rather than answer on knowledge contents. Sloan and Scharff (2022) showed that the use of Knowledge Surveys (KS) results in civil engineering students scoring higher marks. They provided feedback to the students via KS and the competence assessment accuracy was improved after direct feedback.

2.3 Peer Review

A major step change brought by Bologna Process is bringing the students from classic classroom style learning to a more engaging scenario, getting them involved in evaluation process (Conde *et al.*, 2017). Peer review is an essential component used in the research, academia and industry for quality assurance. This process improves the quality of the work and often required at the end of design process. In academia, peer review is applied after completion of the project and before dissemination of the results. Peer review require a high degree of emotional intelligence, critical thinking, art of communicating feedback and being open mind to accept others ideas and excellent interpersonal skills. This process improves student engagement and motivation as they participate in the evaluation process and also encourage independent learning. Gaining peer review skills helps engineers to understand, critique and accept different perspectives and point of view, other than their teachers. Nelson (2000) discussed after a post course evaluation survey that students who were taught peer review skills and who experience peer review during evaluation of a module see themselves at higher comfort level in a professional setting where evaluation is performed by peers. Conde *et al.*, (2017) performed a detailed study on the use of peer review practice in the engineering modules and demonstrated that students group involved in peer review achieved better grades. They also examined that difference between peer review grades and marking by the lecturer. The difference was between 4.7% to 11.5% in the subjects involved in the study. They utilised Pearson product-moment correlation method and determined that a strong and significant correlation exists between teachers and peer review evaluation. In the feedback of this study, students recommend that a well structured rubric is necessary for evaluating their peers. In a study on teaching of peer review skills to electrical and computer engineering classes, Ekoniak *et. al* (2015) examined two groups of students. One group was given in-class training by the lecturer on the process of peer review through lessons, workshop and teaching contents and the second group was handed over the teaching material only. The authors compared peer reviews performed by the two groups and demonstrated no statistically significant difference between the two groups. The study concluded that it is not necessary to teach the peer review methods to the students in the class and handouts explaining the process are sufficient to introduce this skillset. The involvement in the practical peer review process is however important, as students gain experience in techniques used during the process. Cho and MacArthur (2010) demonstrated that students who received review from multiple peers improved their writing skills to a higher level comparing to those who received feedback from a single peer. This signifies the importance of receiving feedback from different people and perspectives.

2.4 Blog Writing

Blog writing is a classic method used in language courses, social sciences and business educational programmes (Marvell, 2018). In engineering programmes, technical reports, articles and report writing are commonly used to introduce writing skills and develop knowledge in specific areas (Chaikovska *et al.*, 2022). Blog writing however provides a platform for the students to write about

a topic according to their own understanding and post it on electronic media to receive comments and feedback and provide a response to these comments. Blog writing process and engaging with the fellow students on a certain topic enhance the students knowledge in specific topic, improve their writing skills, enhance interpersonal skills and appreciate feedback from peers. The best characteristic of blogs and comments is limited number of words which capture readers attention and ability to convey the message effectively in short reading time.

4. CONCLUSIONS

The prevalence of Industry4.0 and disruptive technologies in the engineering industries demand future talent workforce who will act as transformational leaders to address the current challenges and meet several goals set for green and digital economies. Challenge based learning has been popular and introduced critical thinking skills in the engineers. For the future leaders, critical thinking skills must be combined with excellent interpersonal, responsibility, decision making, emotional competence and entrepreneurial qualities. Teachers of engineering programmes have a well described and structured technical teaching contents which must be delivered as a whole for successful delivery and completion of the technical courses. Therefore, limited time is available in technical modules for teaching of soft skills. The innovative teaching methods, including business canvas model, self assessment, peer review and blog writing are proved to be successful techniques for equipping the students with transformational skills. These methods require minimal or no change in the technical contents of the modules and can be integrated into the continuous assessments, resulting in huge benefits for both teachers and students.

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