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Analysis and Reconfiguration of the EM106-Project and Technical Drawing for the Purpose of Second-Level Gifted Education †

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Abstract: Goldberg and Somerville write of the "missed revolutions" that have had a massive impact on industry but have failed to translate to universities. The literature shows how alternative approaches can modernise curricula and improve motivation and trust, such as student-led design of course content. Aligning what is taught to students to improve their experience rather than performance is a method discussed by Obada as constructive alignment. This paper outlines the potential challenges facing engineering education, including a lack of motivation and trust between students and educators and the lack of development of communication skills in graduates. This research aims to use the EM106-Project and Technical Drawing, an undergraduate module at DCU, as a framework by which to test novel curriculum design and pedagogical methods. A modified version of the module will be delivered to second-level students taking part in a dual enrolment programme, with first-year undergraduate engineers taking the standard version of the module. Their experiences will be compared to understand the impact that changes have on student's views of engineering.

Keywords: education; design; curriculum; gifted education

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1. Introduction

The EM106-Project and Technical Drawing, as a year-long project-based module, introduces engineering students to design. Basic computer-aided design is introduced through SOLIDWORKS training before setting a group design assignment of an automated guided vehicle (AGV). The pre-existing pedagogy focuses on introducing students to basic engineering drawings and manufacturing, using mathematical analysis to determine the dimensions of the vehicle. This introduction occurs in the first semester, with the second semester focusing on manufacturing the AGV. While this structure does achieve the learning outcomes detailed in the module descriptor, it is asserted that the restrictive nature of the design document and the lack of integration of SOLIDWORKS in the AGV design leaves student continuing through their undergraduate degree with little knowledge of conceptual design.

The proposed redesign of the module would take the form of a complete restructuring, with experienced engineering design lecturers helping form the new curriculum. This, along with a reimagining of the learning outcomes and teaching methods used, should leave undergraduates with more advanced knowledge and confidence in conceptual design while maintaining the core knowledge students require in later years.

This research seeks to analyse these changes to design education through the lens of gifted youth education with the Centre for Talented Youth Ireland (CTYI) through their dual enrolment programme, Early University Education (EUE). Dually enrolled students bring a unique perspective to engineering education, and smaller class sizes and student motivation allow for detailed analysis prior to applying the changes to undergraduate classes.

2. Interpretation of the Literature

Initial research focused on identifying the potential challenges facing engineering education to view how these challenges could manifest in design education at DCU. A major challenge that was identified was a lack of education surrounding communication skills in engineering. Research from Flowers [1] and Holik and Sanda [2] shows extensive examples of graduates entering the industry with good technical abilities while lacking professional communication skills. These communication skills can be difficult to teach directly in an engineering environment. Another challenge discussed in the literature is that of motivation and trust. Deci and Ryan [3] discuss intrinsic motivation, driven by student's interests. This is opposed to extrinsic motivation, driven by external factors, such as societal pressure, exam scores, or the promise of high salaries upon graduating. There can be an underlying assumption that the student cannot be trusted with their own education, which can lead to a disconnect between the student and educator [4].

Potential solutions researched presented themselves in the following two forms: curriculum design and pedagogical methods. The curriculum design solutions discussed in the literature focus on methods by which to modernise the courses taught to engineers, both format and content. Pedagogical methods in the literature, while mainly discussed within the framework of humanities or social sciences education, offer novel solutions to the challenges facing engineering education, using methods to increase intrinsic motivation in students by increasing autonomy through active learning [5], offering more structured support through scaffolding [6] and using different questioning techniques to improve engagement [7].

3. Research Structure

The goal of the research project was to form the modified EM106 module based on the challenges and solutions discussed previously. This design phase considers potential methods of application that have been implemented at other third-level institutions and their impact on design education.

The impact of these changes on the module is analysed through the application of the changes to the EUE programme, with undergraduate students taking part in the standard EM106 acting as a control group. These changes to the EUE programme reflect the solutions found in the literature, with a focus on increasing intrinsic motivation [3] and communication skills [2]. This will be achieved through applying new methods such as scaffolding [6] and novel questioning methods [7]. The curriculum will also be designed with these focuses, using methods such as constructive alignment [8] and participatory design [9] to create a student-first curriculum, following the curriculum design methods used at institutions such as Olin University [10] in their Design Nature programme and the National University of Singapore in their Innovation and Design programme.

The sample can, therefore, be split into the following three groups:

1. Lecturers at third-level institutions with experience in design education;
2. First-year undergraduate engineers sitting EM106;
3. Early University Entrance students sitting the modified version of EM106.

Lecturers will be asked about their experiences in and the structure of first-year design education at their institution. This will help inform the decisions surrounding the solutions found in the literature and their effectiveness in third-level engineering education. Considerations will be made in these discussions regarding the difference in available resources and entry-level knowledge of students.

The groups of students will be asked to participate in questionnaires and focus groups. The questionnaire will focus on students' opinions of the importance of multiple different competencies in engineering and their ability in these competencies. These competencies will range from typical engineering skills (problem solving and innovation) to communication and interpersonal skills (written communication, teamwork ability) to skills not normally associated with engineering (understanding of contemporary issues, citizenship).

The focus groups will concentrate on their interests in engineering, their confidence in conceptual design, and their experience in EM106. These focus groups will help gather more detailed and nuanced opinions from students, as well as allow students from different teams to interact and share opinions.

The questionnaires and focus groups will be given to both sets of participants twice: at the beginning and end of their participation in EM106. Upon completion of the team-based project, teams will also be asked to take part in a project debrief to summarise their experience with the project, including how they worked as a team and tackled difficult aspects of the project.

The results from both groups will be compared, with the undergraduate cohort acting as a control group. Considerations will be given during this comparison due to external factors such as differences in time, entry-level knowledge, and motivation among others.

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Informed Consent Statement: Informed consent will be obtained from all subjects involved in the study.

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