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Modern Teaching Initiatives for the Effective Development of Transferable and Employability Skills

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CONTEXT

Numerous studies worldwide indicate that university graduates often lack transferable skills, or employability skills, upon graduation. The bulk of studies however do not consider the use of problem-based learning (PBL) as a means of training for transferable skills development, which could prove to be a more effective approach.

PURPOSE OR GOAL

The key objective of this research is to analyse the effects of PBL in teaching and developing transferable skills to undergraduate students at the School of Engineering in Macquarie University. This study reviews some modern teaching initiatives implemented in one of our SPINE (Scaffolded Professional Development in Engineering) units, ENGG1050, for the effectiveness of transferable and employability skill development. The study investigates student experience from feedback regarding the use of various teaching implementations including an online interactive platform “Miro”, podcast-based lecture videos and a range of weekly interactive PBL activities. The review also sheds light on the importance of a tutor training program in scaffolded instruction delivery for the administration of this unit.

APPROACH OR METHODOLOGY/METHODS

The School of Engineering at Macquarie University has a set of unique and integral units known as the SPINE which spans across the four-year engineering degree program. It is designed explicitly to introduce and develop transferable and employability skills using PBL and scaffolded instructional pedagogies. Specifically, the second unit in our SPINE series, ENGG1050, which runs in the second semester of the first year, has been designed to explicitly address teamwork and the development of a professional brand. This unit includes online modules and an online PBL activity. The PBL is a contextualisation vehicle for students to apply the learning that has been introduced via the online modules. These modules cover topics such as structured problem solving, team formation, collaborative teamwork behaviours and accountabilities.

A student survey was used to investigate student experience from feedback and the impact these teaching initiatives have on their development of employability and transferable skills development. The study also contains a review of modern teaching initiatives implemented in this type of first-year subject.

ACTUAL OR ANTICIPATED OUTCOMES

The use of an interactive platform such as “Miro” for the development of a team charter, project plan, and project timeline greatly enhances students’ engagement and participation. The use of podcast videos lectures is a modern approach to a conventional didactic lecture series which has been found to attract and resonate with this generation of student cohort, further enhancing their engagement in the subject matter.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY
The combined use of PBL initiatives is an effective method of delivery and instilling transferable skills such as Teamwork ability and collaborative skills development in first-year Engineering students. The combination of online and digital modalities is an effective and well-received method of interacting with students of this generation (millennials/digital natives). Due to the nature of the scaffolded instructional nature of the PBL approach, the tutor training program is an important part of the administration of the unit. Future recommendation for similar work is to consider scalability factors when designing and running large PBL units with scaffolded instructions.

KEYWORDS
Employability skills; Scaffolded Instruction; Teamwork; Modernisation; Collaboration; Problem Based Learning (PBL)

1. Introduction

There have been multiple studies throughout the world which indicate the lack of development of soft skills – also referred to as transferable or employability skills – in undergraduate engineering students from universities.[Veiga, 2017; Pereira & Costa, 2017] In the new social era, transferable skills are now regarded as vital to the progression and security of engineering graduates' employability. [Lowden et al. 2011, Dogara et al. 2021] In addition to technical challenges, engineering graduates must tackle other complex professional and personal challenges to thrive in the work industry. This requires extensive knowledge and skills from their focused areas to tackle these challenges while achieving viable and sustainable solutions to complex modern engineering problems. Furthermore, transferable skills such as independent and autonomous learning (agency), digital literacy, communication skills, tolerance to criticism, team play, leadership, social interaction or assertiveness and empathy, play a huge role in their professional development.[Rodrigruez et al. 2021, Schulz, 2008] Many authors advocate that exposure to technical skills alone in their undergrad degrees is inadequate for graduates to secure jobs and to be effective at work.[Dogara et al. 2020, Keller et al. 2011, Shafie and Nayan 2010] Moreover, some literature highlights that companies are currently facing difficulties with graduates due to inadequate transferable skills and highly recommend that graduates ought to acquire transferable skills.[Sodipo 2014, Pitan & Adedeji 2010] The students are expected to finish their undergrad with a highly competitive curriculum focused on technical and soft skills such as teamwork and communications.[Eggleston & Rabb, 2018; Riemer, 2002] In the past two decades, the industry is encouraging the development of a soft-skills-based curriculum and expects active student participation in the teaching-learning processes. In response, the universities are developing and introducing new curriculums at various levels of engineering education. The problem with teaching soft skills is the lack of consensus on how to assess which of the skills are most important or even how to teach them. [Rodriguez et al. 2020] This derives from the general acceptance that soft skills need to be learned actively, in opposition to the technical skills that are classified as raw knowledge and can be learned passively. The bulk of studies in various disciplines indicates an improvement in various soft skills, including hard skills, through implementing the problem-based learning (PBL) approach. [Brata, D & Mahatmaharti, A. 2020] Problem-based learning is an efficient teaching tool that develops a range of transferable students' skills through contextualised learning and focusing on domain-specific knowledge. Thus, engineering education uses PBL as its preferable pedagogical tool. [Tse 2019]

Here at School of Engineering of Macquarie University (MQ), the engineering undergraduate curriculum consist of a suite of units known as the SPINE units. These units are unique and integral part of the program of study and have been designed to explicitly teach these employability skills through PBL. Specifically in the 2nd unit of this series is the unit ENGG1050 which has been designed to explicitly deliver the development of teamwork and professional skills.

This unit simulates an engineering industry setup by immersing the students in a team-based work environment. They are challenged to solve an ill-defined problem using fundamental skills and knowledge. The students are exposed to online modules and podcasts, which, together with project-based learning and PBL activities, should develop their transferable skills and improve their professional competencies. This innovative approach should prepare them to solve any advanced and specific engineering problem.

While the subject involves larger groups of students working in groups, multiple tutors are assigned for the supervision of those groups, no more than 4 groups per tutor. In order to ensure consistency in the subject delivery and ensure constant quality monitoring, the subject introduces a tutors training program that simulates situations where students are provided with the agency for independent learning with minimum supervision.

The use of an interactive platform such as “Miro” for team charter, project plan, project timeline assists students’ engagement and participation. Introducing podcast videos for lectures is a modern attempt in the subject to enhance students’ engagement in online lectures. Therefore, the main objective of this study is to analyse the effects of PBL in improving and developing transferable skills in undergraduate engineering students at MQ via student feedback survey. The study will review modern teaching initiatives implemented in the subject ENGG1050 for the effectiveness of transferable and employability skill development. Moreover, the study will investigate students’ experience and feedback regarding the application of podcast-based lecture videos, the use of “Miro” as an interacting platform for students’ teamwork, and the impact of tutors training in the subject delivery.

2. Research Method

In this study, a systematic literature review is undertaken to understand the existing pedagogical innovations for the delivery of employability skill training in undergraduate students. Empirical research associated with qualitative data and quantitative analyses were conducted to examine students’ experience impact by the contemporary teaching methods designed in ENGG1050 to enhance employability skills in teaching first-year engineering subjects. The teaching content, the delivery details of each activity involved in the subject and the intended learning outcomes of the subject is provided in Table 1.

Table 1. Teaching schedule, activities relating to intended learning outcomes for ENGG1050

Name of task (Weighting)	Due date (week)	Description (Learning Outcome)
A0. Attendance (0%, hurdle)	Weekly	Participation and attendance to small group teaching that are hosted online. (LO3)
A1. Professional development (15%)	12	LinkedIn public profile development. (LO2,5)
A3. Periodic quizzes (20%)	1,2,3,8,9 and 10.	Online quizzes (LO1, 4, 5)

A2. Technical writing (15%)	8	A simulated experiment where students are exposed to the procedure of material testing and are tasked to communicate technical data in a layperson technical report. (LO2)
A4. Project (45%)	13	A Rube Goldberg Challenge where students work in a team to deliver a final project outcome. Through this project, students apply the key teamworking skills and communication skills required to deliver a project outcome. (LO1, 2, 3 and 4)
A5. Reflection (5%)	7 and 13	Two reflective documents, students are tasked with describing how they have develop/improved on a given set of transferable skills and demonstrating the relation of these experience with internalised reflection. The students use the STAR techniques to articulate the recount and the DEAL model for reflection. (LO5)

According to the University's handbook for ENGG1050, the related Unit Learning Outcomes (ULOs) are:

- ***ULO1****: Evaluate an engineering problem and enumerate related constraints and requirements.*
- ***ULO2****: Communicate an engineering problem and associated solutions professionally, both orally and in writing.*
- ***ULO3****: Employ strategies to collaborate effectively with a team on solving an engineering problem.*
- ***ULO4****: Apply the structured engineering design process framework in defining and solving imprecisely defined engineering problems.*
- ***ULO5****: Apply constructive techniques to reflect upon positive and negative experiences for personal and professional growth.*

A set of survey questionnaire was developed to investigate the effects of activities used in developing soft transferable skills in the undergraduate students. Specifically, the question invested the type of teaching content and resources used as well as the mode of delivery that was used within the project-based learning (PBL). The set of question was approved by the MQ ethics committee, and the responses were kept anonymous. (Table 2)

Table 2. Ethics approved survey questionnaire used in this study.

Question statement	**Overall/ General**	**Implementation**
Q1 The podcast videos on different lecture topics were highly engaging and more effective than other conventional lecture methods.		Podcast
Q2 Weekly engagement via Miro for team charter and team activity improved my involvement with my teammates and helped me to be more engaged and active within my group.		Miro
Q3 Exposure to DISC assessment made me understand my weaknesses and strengths and enabled me to leverage upon my strengths and improve my weaknesses.		DISC
Q4 The reflection exercises using STAR approach were essential for solving the problem in hand and improving the team outcomes.		STAR reflection
Q5 Rube Goldberg Machine project greatly assists me in my and working in a team as a member skill.		RGM project

Q6 The subject is greatly assisting me in my professional development.	*	Teamwork
Q7 The subject assisted me in learning critical thinking and problem-solving skills.	*	
Q8 Weekly presentations followed by the final presentation gave me in-depth knowledge and sufficient practice to improve my presentation skills.		Weekly Presentation
Q9 The unit conveners and tutors were doing justice to the delivery of the subject.	*	Tutors' engagement
Q10 Having an opportunity to work with different tutors enriched my development as a professional.		Tutors' rotation
Q11 I have developed agency of learning teamwork skills throughout this project environment.		
Q12 Overall, the subject was very useful for my engineering degree.	*	

The survey questions were administrated using Qualtrics MX and survey link was made available via the learning management system iLearn. There was a total of 12 questions, all of which used a Likert scale of disagree, strongly disagree, neither agree nor disagree, somewhat disagree, agree, somewhat agree, and strongly agree. The questions were categorised based around the teaching implementation and proxy questions for how the unit was received overall. The survey did not capture any student data and hence remain anonymous. Of the 75 enrolled students, 62 responded to the feedback survey (82.7% responds rate).

3. Results and Discussions

3.1 Literature review

Enhancing the employability of students by developing their transferable skills via engineering curricula has continued to draw an enormous amount of attention from various stakeholders in the education industry worldwide. [Dogora et al., 2020; Cimatti, 2016; Robles, 2012] Many researchers agree that passive learning is not an effective means for developing transferable skills in students. Students need to be given a situation where they can adopt an active role while understanding their goals, responsibilities, competences, weaknesses, and strengths in relation to transferable skills. [Dogora et al., 2020], which includes role-playing game or active classroom discussion. Expository, active, and guided strategies are the three groups used to teach transferable skills by the ModES (Modernizing Higher Education Through Soft Skills). The nature of engineering work depends on professional and transferable skills due to the constantly varying design parameters. The PBL uses project-based learning tools to develop any transferable skills effectively. Table 3 shows the teaching implementation used in ENGG1050, which has been classified via the ModEs framework.

Table 3: Teaching Implementations used in ENGG1050 classified by the ModEs framework.

Classification by the ModEs framework	Implementation used in ENGG1050
Expository	DISC, Podcast, STAR reflection
Active	Miro, Teamwork, Weekly Presentation

Guided	RGM project, Tutors engagement, Tutors rotation

In this subject, students are required to undertake a project to develop a Rube Goldberg Machine (RGM) to help them complete simple tasks in a complex way. The students are divided into smaller groups (group of 5) and are provided with one tutor as their academic mentor for the first 6 weeks. Every week students are to attend a scheduled online workshop with minimal tutor supervision as students are given the agency (autonomous learning) to run their weekly meetings, plan for their weekly activities, adhere to their team charter, take weekly meeting minutes and perform team reflection on their experience and learnings using the STAR approach. To ensure consistency with tutors' approach to scaffold students' learning, one-hour tutor training session is held prior to students' regular workshops. Conventional lectures are replaced with podcasts. Podcasts have become a significant part of this century and gradually started to be important in higher education as a teaching and learning tool. Studies show that when podcasts are used in the curriculum, there is an improvement in students' knowledge retention, motivation, and collaboration. There are also benefits to equality and inclusion among the students [Lonn & Teasley, 2009; Stoltenkamp et al., 2011; Widodo & Gunawan, 2019]. Weekly presentations, weekly meetings, weekly minuting as in professional setups, are some other activities planned in the subject with the aim of getting students' active participation help them develop transferable skills. In the very beginning of the subject, students are required to undertake DISC assessment which is a personality type analysis to explore one's weaknesses and strengths as an individual which is very helpful in team charter to complement their teamwork.

3.2 Feedback from the survey

A standard online survey administered in Qualtrics was set for the students to undertake at the end of the semester. The evaluation consists of 12 questions as shown in Table 2. All these questions directly relate to addressing how different activities designed in the subject and different learning resources and assessment tools used in the subject supported improving students' transferable skills learning.

Overall/ General		Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	TOTAL	Teaching implmentation	Teaching purpose / softskills development: Content exposure	Agency	Integration	Teamwork	Reflection (introspection)	Communication skills	New perspectives	Critical thinking
	Q01	8%	20%	23%	35%	13%	100%	Podcast	x							
	Q02	5%	15%	10%	37%	33%	100%	Miro				x				
	Q03	15%	18%	23%	30%	13%	100%	DISC		x		x				
	Q04	17%	8%	22%	34%	19%	100%	STAR reflection		x	x		x			
	Q05	10%	10%	15%	42%	23%	100%	RGM project	x	x	x					
*	Q06	15%	15%	18%	27%	25%	100%	Team work								
*	Q07	13%	10%	15%	40%	22%	100%			x						x
	Q08	5%	15%	15%	30%	35%	100%	Weekly Presentation				x		x		
*	Q09	14%	14%	15%	36%	22%	100%	Tutors engagement	x			x				
	Q10	5%	8%	18%	47%	22%	100%	Tutors rotation	x			x		x	x	
	Q11	3%	8%	10%	58%	20%	100%	RGM project		x		x				
*	Q12	20%	10%	17%	30%	23%	100%									

Figure 1: Results from survey

3.2.1 Key discussion points

From our systematic study, it can be observed that a majority for student responses are positive with over 60% of responses in the agree/strongly agree category that the teaching implementation used has greatly helped with development of transferable skills. (Table 4)

Table 4: Overall result from question Q6, 7, 9 and 12 which are proxy question for how the unit was received.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Q06	15%	15%	18%	27%	25%
Q07	13%	10%	15%	40%	22%
Q09	14%	14%	15%	36%	22%
Q12	20%	10%	17%	30%	23%

Table 5: Data on how each teaching implementation were received by the students. (Ranked from the most agreed to the least)

Question	Teaching implementation	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Total
5,11	**RGM project**	7%	9%	13%	50%	22%	100%
2	**Miro**	5%	15%	10%	37%	33%	100%
10	**Tutors' rotation**	5%	8%	18%	47%	22%	100%
8	**Weekly Presentation**	5%	15%	15%	30%	35%	100%
4	**STAR reflection**	17%	8%	22%	34%	19%	100%
1	**Podcast**	8%	20%	23%	35%	13%	100%
2	**DISC**	15%	18%	23%	30%	13%	100%

Specifically, a breakdown based on the implementation was also evaluated. Table 5 shows the relevant questions that investigated the effectiveness of teaching implementation used within the unit along with the responses. It was observed that the project-based activities (RGM project) were the most well received and viewed as the most engaging amongst the list of teaching implementations. This maybe because PBL is more commonly accepted as a conventionally engaging teaching implementation (or learning activity) compared to the list herein. Whereas profiling tests such as a DISC analysis, to a first-year student, is not something they have been accustomed to. Future studies may be extended to evaluate correlations between students' familiarity of a teaching implementation and the effectiveness of that teaching implementation. Also, how effective psychometric or profiling are for developing transferable skills awareness. There has been reports that psychometric tests are a good introductory activity for developing appreciation of transferable skills. [Snape, 2017] Miro was well received, as per anticipation upon choosing this as a predominate collaborative tool. This may be due to the intractability of the visual elements that are employed by Miro virtual platform. [Schuh, 2014; Smeda, 2014]

Table 6: Aggregated data on skills development (Ranked from the most agreed to the least)

Question	Development	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Total
1,5,10	**Content exposure**	8%	13%	19%	41%	19%	100%
10	**New perspectives**	5%	15%	10%	37%	33%	100%
8,10	**Communication skills**	16%	13%	23%	32%	16%	100%
3,4,5,11	**Agency**	7%	11%	16%	39%	27%	100%
2,3,8,10,11	**Teamwork**	10%	11%	18%	42%	18%	100%
4,5	**Integration**	4%	8%	14%	52%	21%	100%
4	**Reflection (introspection)**	5%	15%	15%	30%	35%	100%
	Critical thinking	-	-	-	-	-	-

Using aggregated statistical methods, the results from the survey were grouped based on the teaching implementations and what the teaching implementation was aiming to develop. From that, the average Likert value was computed. Table 6 shows the result that a majority of students find the teaching implementation effective in delivering training and development for the listed soft and transferable skills. The overall survey result suggest that content experience/ new perspective was well received. However, the two key elements of Agency and Teamwork were perceived as not as well delivered with the current teaching implementation. An equal portion of students feel that it is not effective in simulating true teamwork. It was also noted that Reflection activity was least well received. One possible explanation of this may be founded from the LEU feedback. Where a student remarked:

> ***"…everyone had to hand in their second reflection blindly because we had not received our marks or feedback for the first one…".***

This feedback suggested that Reflective practices is highly depended on the level or feedback required for learners to fully appreciate the positive effect reflective practice has on development. [Calvillo et al. 2022] The level of feedback provided for this activity this semester however was lacking due to staffing issue and other administrative activities. This would have negatively affected how the activity may be perceived by students.

Table 7: Aggregated data based on the ModEs Framework of categorised activities. (Ranked from the most agreed to the least)

Question	Grouped by ModEs framework	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Total
5, 10, 11	Guided	6%	9%	15%	48%	22%	100%
2, 8	Active	5%	15%	13%	33%	34%	100%
1, 2, 4	Expository	13%	16%	23%	33%	15%	100%

From Table 7, the students have reported that the most favoured activities ranked from Guided (RGM project, Tutors engagement, Tutors rotation) to Active (Miro, Teamwork, Weekly Presentation) to Expository (DISC, Podcast, STAR reflection). The result is somewhat contradictory to the reported literature where students generally prefer active learning over guided learning. [Tomas et al., 2019; Tharayil et al. 2018] One possible explanation of this may be that a junior first year students, transitioning from a schooling environment, they are more accustomed to a guided learning environment as opposed to full active learning they have the drive their own development. [Tomas et al. 2019]

4. Conclusion

The new teaching implementations are generally well received. This is especially true when paired against a certain skills development such as Content exposure/new perspective and communication. The key development however, that are Agency and Teamwork are still lacking. Also, the teaching implementations of a reflective writing piece was not fully endorsed by the student community. This however is not unheard of as adolescent does not have the tendency for journaling.

In addition to technical challenges, engineering graduates need to tackle some other complex professional and personal challenges to thrive (or even survive) in the work industry. Previous investigations suggest that there is a lack of development of transferable skills, also known as transferable, generic or employability skills in undergraduate engineering students at the tertiary education level. Despite a growing interest in highlighting transferable skills in

curricula, there is not any collective understanding (nor prioritising) of which skills are more important in engineering studies.

On the other hand, pedagogical approaches of teaching transferable skills exhibit a high degree of variability. Problem-based learning is ubiquitous – and yet becoming highly preferred pedagogy – in the field of engineering education. Here at the authors' affiliated institution, the School of Engineering of Macquarie University (MQ), the engineering undergraduate curriculum consists of a suite of units known as the SPINE units. These units include a set of modules presented online, electoral and PBL activities, and introduce engineering challenges that require knowledge in dealing with engineering ill-defined concerns.

This study examines modern teaching initiatives implemented in the subject ENGG1050 for the effectiveness of transferable and employable skill development required to deal with advanced and domain-specific engineering problems. Moreover, the study investigates students' experience and feedback on the application of podcast-based lecture videos, the use of "Miro" as an interacting platform for students' teamwork, and the impact of tutors' training on the subject delivery.

Throughout the RGM project, it was observed that the project-based approach was the most well-implemented and engaging approach for the SPINE units. This may be attributed to the fact that PBL was commonly accepted as a conventional and nationally engaging teaching implementation, unlike the DISC analysis approach.

Using aggregated statistical methods, the results from the survey were grouped based on the teaching implementations, whereby the average Likert value was computed. The overall survey result was that content experience or new perspective was well received by the students in the target cohort for the SPINE unit in question. However, the two key elements of Agency and Teamwork were perceived as not as well achieved with the current teaching implementation. The most favoured activities ranked as Guided (RGM project, Tutors engagement, and Tutors rotation) through to Active (Miro, Teamwork, Weekly Presentation) and Expository (DISC, Podcast, STAR reflection). The result is contradictory to the reported literature where it was reported that students preferred active learning over guided learning. This is attributable to the fact that the target audience for this project was junior (first year) students, transitioning from a school environment, who were accustomed to a guided learning environment as opposed to full active learning.

Future work

Future studies can examine how effective a teaching implementation may be relative to how well-versed a student might be in a particular method of teaching implementation. Future research can also elaborate on how effective psychometric studies would be in developing transferable skills.

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