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Systematic Literature Review of Students' perception of Employability Skills

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ABSTRACT

CONTEXT
Over the years, research investigating how engineering education contributes to the employability skills of students has led to the adoption of scenario-, problem- or project-based learning being implemented as effective methods for developing skills. Measuring student perception has emerged as an effective tool to gain insights into how changes to engineering curricula can contribute to various skills and attributes of engineering graduates. The COVID-19 pandemic has, however, disrupted teaching methods, making student engagement challenging. The effectiveness of teaching methods is dependent on the students' engagement level, which in turn translates into developing their employability skills.

PURPOSE OR GOAL
In order to pave the way for the post-pandemic approach towards improving the employability skills of engineers, it is important to gain a comprehensive understanding of the existing literature in this area of study. Thus, the aim of this study is to conduct a systematic literature review of undergraduate engineering students' perceptions of employability skills.

APPROACH OR METHODOLOGY/METHODS
Utilising the PRISMA protocol, a systematic review of the existing literature will be performed, looking at student perception of employability skills. The review will look at peer-reviewed research reporting on post-secondary engineering education in the last 20 years. Highly relevant papers will be chosen based on the protocol and reviewed.

ACTUAL OUTCOMES
Throughout the literature on this topic, a recurring theme is that employability skills are not well-defined, and a range of reference frameworks are used, such as accreditation requirements, 21st century skills and global engineer skills. The review found that the employers perceive that graduating engineers' non-technical skills are inadequate. In response, universities are constantly evolving their curricula and teaching methods to address this gap. Mismatches are identified in terms of the student perceptions of important employability skills and the perceptions of universities and industry employers. Internships, job placements, and problem- and project-based learning have found their place in helping undergraduate students to develop their skills. Suggestions for future work include a comparison with other professional degrees and how engineering education has deviated from these other degrees.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY
The effect of COVID-19 on engineering student's employability and how long it will persist is currently unknown. This study contributes to the understanding of student perceptions about employability skills before the pandemic to understand the state of play when the COVID-19 disruption to teaching and learning occurred. It adds to the growing body of knowledge on engineering education focussed on employability skills and will help develop this field progress as we emerge from the pandemic.

KEYWORDS
Systematic review, student perception, employability skills, teaching methods, engineering

Introduction

Historically, engineering education was dependent on a master-apprentice relationship where the master played the role of not only training the apprentice in technical knowledge but also providing guidance with non-technical skills to be a valuable member of society. This had been the practice for hundreds of years, and when technical advancements and knowledge creation began to explode after the industrial revolution, the role of training engineers for society eventually became the responsibility of universities (Bagherzadeh et al., 2017). Over time, this has brought the engineering education field to the present situation where the responsibility rests with tertiary educators to impart both technical and non-technical skills to engineering graduates, with employers demanding job-ready engineers for the workforce.

The employability of engineering graduates has drawn much attention in the past three decades, necessitating changes in the targeted graduate attributes of students and the accreditation requirements of university courses (AlMunifi & Aleryani, 2019; Cruz et al., 2021; Franklin et al., 2012; Martin et al., 2005). The 1990s signalled a transition in accreditation requirements from basing them on time spent on teaching the requisite subjects to a focus on the qualities and attributes with which engineers should graduate (Martin et al., 2005).

The general view among employers within the industry is that among the engineering graduates, there is a shortage of non-technical skills, making them less work-ready for the demands of the engineering profession (Itani & Srour, 2016; Lee & Chin, 2017; Rizwan et al., 2021; Simmons et al., 2021; Thirunavukarasu et al., 2020). In response to this notion of skill gap, universities have made changes to their pedagogy and adopted approaches such as project-based learning (Bozic et al., 2014; Jaeger & Adair, 2018; Williams & Ringbauer, 2014), flipped or hybrid classes (Cano & Garcia, 2020; Rodrigo-Peiris et al., 2018), included internship subjects (Mohd Salleh & Yusof, 2017), and organised skill-specific out-of-semester camps (Gerhart et al., 2015). However, other professional degrees, especially in the medical field, have integrated job placements and other forms of employment training into the curriculum (Sharghi et al., 2015) to good effect.

Employability skills are referred to in the literature variously as ‘professional skills’, ‘soft skills’, ‘non-technical skills’ and ‘core skills’, amongst others, and do not have a universal definition (Itani & Srour, 2016; Jesiek et al., 2010). However, some of these commonly accepted skills that feature in the literature are communication, teamwork, problem-solving and interpersonal skills, with skills such as engineering ethics and lifelong learning also prominently entering the discussion.

We see that employers are expecting well-rounded graduates, universities are constantly innovating course structures, and students are upskilling themselves to be employable. Amidst this engineering ecosystem, the COVID-19 pandemic has significantly disrupted the higher education system. Admittedly, the coronavirus pandemic has distorted every walk of life, but this paper will specifically be contextualised around how this pandemic has affected engineering education.

COVID-19 has forced universities to adopt an online teaching medium due to the lockdowns and restricted physical movements, which is still in place in several parts of the world, including Australia. This forced adoption has disrupted the approaches designed to make university students more employable, such as internships and work-integrated learning (WIL). Students and employers are understandably concerned that skill development may be affected. It is important to understand how employers and students perceive how skill development has been impacted by the pandemic, specifically in terms of employability skills. This understanding, in conjunction with the literature of the past, will help educators develop the engineering pedagogy for an effective ‘new normal’ and ensure that employers have confidence in the skills of our graduates.

As a first step in investigating the effect of the COVID-19 disruption on the development of employability skills in university students, this paper reports on a systematic literature review

of the undergraduate engineering students' perceptions of their employability skills. This review will form the basis of a future student perception survey investigating how the pandemic has affected the undergraduate engineering students' perceptions of their employability for those who have been learning in the COVID-19 disruption.

Methodology

In order to select literature in an objective and unbiased manner, this review followed the principles of the PRISMA protocol, used extensively in systematic literature reviews in medical journals (Moher et al., 2015). Journal papers were searched on three databases using the Boolean search as described in Table 1.

The inclusion criteria for review the papers were:

1. Papers published in the Past 20 years.
2. Papers published before 2019 should have been cited at least three times.
3. Papers should measure student perception.
4. Perception should be of employability skills/professional skills/generic skills/soft skills, and so on.
5. Students should be studying undergraduate engineering degrees.

Table 1. Prisma flow diagram of the systematic review process

<table>
<tr><td rowspan="6">Identification</td><td rowspan="6"></td><td colspan="2">The search Boolean used was:

(TITLE-ABS-KEY(("student* perception*" OR "undergraduate* perception*" OR "graduate* perception*")
AND
("employab* skill*" OR "professional skill*" OR "soft skill*" OR "generic skill*" OR "graduate* attribute*" OR "competenc*"))
AND
KEY(engineering))</td></tr>
<tr><td>Database</td><td>Number of papers</td></tr>
<tr><td>Scopus</td><td>208</td></tr>
<tr><td>ProQuest</td><td>179</td></tr>
<tr><td>Web of Science</td><td>69</td></tr>
<tr><td colspan="2">Total number of search results = 456</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="8">Screening</td><td rowspan="8"></td><td colspan="2">Duplicates removed, n = 145</td></tr>
<tr><td colspan="2">Abstract and/or Title screening, n = 311</td></tr>
<tr><td colspan="2">Excluded as not published within last 20 years, n = 1</td></tr>
<tr><td colspan="2">Excluded as not related to engineering and/or undergraduates, n = 29</td></tr>
<tr><td colspan="2">Excluded due to less citations, n = 21</td></tr>
<tr><td colspan="2">Excluded as student perception and/or employability skills not studied, n = 190</td></tr>
<tr><td colspan="2">Excluded, full text not available or in a language other than English, n = 4</td></tr>
<tr><td colspan="2">Inclusive list, n = 66</td></tr>
</table>

After screening, 66 papers were selected for the systematic literature review. These papers were further refined by reviewing the abstracts. The output was a star-rating system for the papers, with 5 stars being the most relevant to the topic and 1 star being the least. The criteria for the star ratings are explained in Table 2.

Table 2. Criteria for assigning star-rating to the papers based on relevance to focus areas

5-stars	Undergraduate students' perception is measured exclusively	✓
	The main focus of the paper is employability/professional skills	✓
	Compared with industry standards/employer expectations/accreditation requirements	✓
4-stars	Undergraduate students' perception is measured predominantly	✓
	The main focus of the paper is employability/professional skills	✓
3-stars	Student perception is just one of the factors measured	✓
	Employability skills measured indirectly through course/subject outcomes	✓
	Undergraduate engineering students not focussed exclusively	✓
2-stars	All the focus areas are loosely studied	✓
	Indirectly covers the topic area	✓
1-star	The focus area may or may not have been studied. It can only be verified in full text.	✓

Using the star rating resulted in 38 papers with ratings of 3-stars or less and 28 papers of 4- and 5-star ratings. Of the 28 papers, five papers were excluded after reviewing the full-text as the conditions of our selection criteria fully emerged while reading the full-text. Thus, after going through the whole systematic process, there was a final paper count of 23 papers, which have been reviewed, synthesised and reported on here.

Results

Ross et al. (2011) surveyed undergraduate engineering students studying in a large Midwestern University in the United States of America (USA) with a focus on the students' inclination towards lifelong learning and how they use their information skills to achieve this. They found that the students considered themselves competent at simpler information skills such as defining a problem, citing references and performing self-reflection, whereas the authors found that the students' confidence levels were low with more complex tasks such as critical evaluation, devising alternative solutions and planning courses of actions. The study showed that students lacked the know-how to source accurate and relevant information using various resources such as library databases, indicating a significant barrier to pursuing lifelong learning. They surmise that students who are particularly good at information skills are better at evaluating themselves (Ross et al., 2011). This relates to the limitation where students tend to inflate their competencies during perception surveys, a typical characteristic recognised in most of the papers using such a methodology. This limitation was also noticed by Cruz et al. (2021) where they noticed over-estimation of their skills by students of both undergraduate and postgraduate levels.

In order to determine the skills that undergraduate civil engineers view as crucial for their future engineering practice, Polmear et al. (2020) conducted detailed interviews with thirteen students as an exploratory study and compared the results with a framework derived from professional body guidelines and the expectations of industry practitioners. The authors investigated, out of the 19 competencies identified, how many competencies the students relate to their future success in their engineering careers. Unsurprisingly, there were

widespread acceptance of the well-known competencies, with at least one student deeming 15 of the 19 competencies as important. Four competencies related to engineering, namely, economic fluctuations, engineering ethics, safety requirements, and legal issues, were not identified by even one student out of those interviewed. On the other hand, being passionate about one's job was considered important by the students but did not get featured in the employers' framework (Polmear et al., 2020). Additionally, an understanding of economic trends and business fluctuations by the engineers gained attention in many studies that, in turn, found that engineering graduates generally lack the necessary comprehension in this aspect (Chan & Fong, 2018; Goold, 2015; Martin et al., 2005).

In continuation of the Polmear et al. (2020) study, Simmons et al. (2021) surveyed undergraduate engineering students of eight universities in the USA, with a focus on the students' alignment towards their leadership identity. The students surveyed were from various majors and at various stages of their undergraduate degrees. Based on the theory of Leadership Identity Development (LID), which describes a six-stage leadership transition starting from seeing leadership in others to finally seeing it in oneself, the authors have reinforced the view that leadership qualities are not inherent and rather cultivable. This stresses the importance for educators to identify the students who are in the early stages of this transition and nudge them towards completion by utilising course designs (Simmons et al., 2021).

The impact of the problem- and project-based learning on student perceptions were studied by Mohd Salleh and Yusof (2017) and Estévez et al. (2018), respectively. Although similar, problem-based learning is open-ended with groups of students working together to find a solution, whereas project-based learning has students working to achieve a set target (Chan & Sher, 2014). Yu et al. (2020) specifically studied the impact of project-based learning on students' ability towards collaborative teamwork. Even though working on industrial problems as part of problem-based learning has benefitted students in the form of academic successes and overall employability, some of the students identify a lack of cohesion between the academic supervisors and the industrial supervisors. Additionally, students have varying views about the independence and autonomy accorded to them by their supervisors (Mohd Salleh & Yusof, 2017). Having the students working on time-constrained project-based learning seems to have improved the project management skills of students with notable improvements in creativity, time management, and customer-focussed project deliveries (Estévez et al., 2018). Notable by its absence in these studies was a comparison of the perception before and after the problem- or project-based learning course.

'21st-century skills' was another recurring frame of reference in the literature to study engineering students' perceptions of employability skills (AlMunifi & Aleryani, 2019; Itani & Srour, 2016; Mekala et al., 2020; Tomić et al., 2019). Established by the Partnership for 21st Century skills in 2009, the P21 framework is aimed at making engineering students more suitable for the 21st-century workplace. In a study focussing on the impact of gender and medium of instruction on the Learning and Innovation skills and Life and Career skills defined in the framework, Mekala et al. (2020) found no relationship between the two factors and the two skillsets studied. The authors, however, did find a universal shortage of language proficiency across all the students surveyed, irrespective of the medium of instruction, prompting universities to address this concern.

Another set of skills studied, similar to 21st-century skills, was that of a global engineer (Goold, 2015; Jesiek et al., 2010). Stressing the importance of tacit knowledge and aligning the engineering activities to societal and economic needs, Goold (2015) found that engineering education hasn't caught up to the multidisciplinary profession that engineering practice has now become. In a study of undergraduate engineering students' perception of both technical and non-technical aspects of engineering practice in an Irish institute, the author found that there are significant shortfalls in the non-technical competencies required for global engineers, whereas such differences were not found in the technical skill requirements.

Jesiek et al. (2010) found similar results with engineering students ranking lowest among the 15 skills measured, their ability to use engineering to cater to sustainability, the economy, and society's needs. The students ranked themselves highest in their ability in engineering ethics, teamwork, and decision-making. Additionally, even though the students thought that communication and the ability to work in a multicultural team are important skills to possess, they ranked themselves lowest in these skills. This study revealed that students do think that communication is something that can be developed and is not an innate characteristic (Jesiek et al., 2010).

Itani and Srour (2016) conducted a survey among the senior undergraduate engineers of many Lebanese universities to investigate how much of the gap between university education and industry expectation has been bridged. The authors found evidence of what can be termed as the Rosenthal effect, where engineering students who wished to pursue a non-technical or managerial career gave more importance to the non-technical skills and thereby rated highly, both the importance of the skills and their own evaluation of their skill levels. Chan and Fong (2018) have also found that career aspiration is a vital extrinsic motivation for students to develop their professional skills.

Another outcome from the paper by Itani and Srour (2016) was that the students' perception of engineering and the associated technical skills faced a declining trend as they progressed through their degrees. This could possibly mean that students are disappointed with what an engineering degree entails and a realisation that the field is not what they expected. The authors also state that a lack of the requisite non-technical skills may potentially make it difficult for engineers to transition into a senior management role, and even when they do, it could lead to a career downfall or 'derailment'. This link between career aspirations and imparting of non-technical skills is a factor for universities to consider in designing courses.

Perhaps the most important insight that emerged from the literature review was the impact of internships and work placements on student perception. Lee and Chin (2017) found that students in Singapore who take up engineering following the polytechnic pathway are better at meeting the employer requirements than those students who come from the junior college pathway. This is mainly due to the former pathway offering twice the duration of work placement to the students than the latter. Acknowledging that work placements and internships cannot be universally provided to all engineering students without diluting its impact, Thirunavukarasu et al. (2020) suggests universities co-develop courses and subjects along with the industry partners. The authors suggest promoting a mutually beneficial relationship between the universities and the industries where real-life problems can provide opportunities on which academic innovators can work.

Mark et al. (2018) have found that some of the skills that are needed for self-employment, freelancing and thriving in the gig economy for engineering students are only available at the postgraduate level. They found that STEM students are better with digital literacy than non-STEM students, with the latter having a generally better perception of their own employability skills than the former.

Creativity, innovation and problem-solving, factors that are crucial for success as entrepreneurs, were studied in the papers by Gerhart and Carpenter (2008) and Gerhart et al. (2015). In the 2008 paper, the authors studied the change in perception of engineering students on aspects related to creativity after completing a creative problem-solving course. While before the course, the students did not associate creativity with engineering, after the course, there was a significant change in this perception. From associating creativity with only artists and musicians, the students realised that engineers could also be creative. In the 2015 paper, the authors found similar results after the students engaged with a summer camp aimed at promoting creativity among engineers. The authors also found that after engaging with the summer camp, the students were no longer worried about their solutions failing while solving problems (Gerhart et al., 2015), a very useful attitude to possess as an entrepreneur. These

two papers further reinforce that specific skills can be imparted to the students by designing the curriculum and co-curricular activities suitably.

Discussion and future research

From the systematic literature review conducted, one important insight had emerged when it comes to measuring the student perception of employability skills. There are two perceptions to measure:

1. The skills that engineering students perceive are important for their employability.
2. How the engineering students perceive their skill level.

We feel that it is important for future researchers to measure both in order to tailor the curriculum to suit the student needs. These two approaches to employability skill perceptions are related in such a way that in order to measure students' perceptions of their employability skillset (2), these skills must be described in some way to the students. A suggestion for a combined study would be a survey requiring open-ended responses for identifying important employability skills (1), which could then be analysed for keywords, and students rate their perceived skill for each of these components (2). Semi-structured interviews would also allow students to identify and then rate their skills. Comparing the skills identified in (1) with the accreditation requirements and/or employer expectations would also be valuable.

It is also vital that more studies focus on measuring the perception before and after a particular course that has been specifically designed to improve the students' professional skills or at various points through a degree. Of the seven papers that measured the professional skills after completion of such a course/program, only the papers by Gerhart and Carpenter (2008), Gerhart et al. (2015) and Estévez et al. (2018) measured the 'before' values for comparison.

The disadvantage with self-perception surveys vis-à-vis the inflation of one's own abilities is still yet to be successfully overcome. Chan et al. (2017) and Cruz et al. (2021) are the only authors in this systematic literature review to have focussed on the reliability of the perception survey mechanism. This disadvantage is compounded by the challenge in reliably quantifying the actual employability skills of students. This systematic review has offered insights into the stressors that need to be accounted for in future student perception studies, especially given the COVID-19 pandemic and the restrictions that it has enforced on tertiary education. Of note are the questions surrounding how the students view their skill level when it comes to teamwork, problem-solving and communication in a digital learning medium. It is possible that a lack of face-to-face interaction inside the classroom and challenges faced in offering internships may have resulted in changes in self-perception, with skills such as digital literacy prominently coming to the fore.

This review will form the basis of a future study investigating the perception of students who were forced into an online and remote mode of education and virtual internships due to the pandemic. In the longer run, it would be useful to compare the student perception and engagement across different professions. Professions like legal practice and medical practice do not expect their graduates to be full-fledged professionals from the day they graduate. The employers are part of the transition in their professional identity wherein there is a duration of work placement that helps the medical and law graduates to gain some valuable tacit knowledge. The engineering profession, on the other hand, has moved away from this practice significantly, and as seen from the literature review, employers have started to expect ready-made engineers from universities. It is an opportunity to investigate what this means to engineers as the problem-solvers and the infrastructure builders of society.

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