# FUTURE OF WORK: INNOVATION SKILLS AS THE MISSING LINK FOR EMPLOYABILITY

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## ABSTRACT
While innovation is critical for the workforce of tomorrow, the curricula of current science, technology, engineering and mathematics (STEM) education programs do not sufficiently prepare graduates with innovation skills for the future of work increasingly characterized by automation and artificial intelligence. This quantitative, longitudinal study measures key transferable skills in work integrated learning (WIL) students, before and after their industry placement. It found that students were deficient in important innovation skills needed for employability in the future workplace including creativity/lateral thinking, entrepreneurship/ intrapreneurship, influencing others and conflict resolution. The study also demonstrates how feedback on transferable skills development could be an effective tool used for professional development of students, improvement of their innovation and employability skills and increased awareness of an innovative mindset. The study offers implications for educators in nurturing innovation skills though enhanced curriculum development and delivery, robust measurement and feedback to students.

**KEYWORDS:** curriculum design, employability, entrepreneurship, innovation, STEM, student career literacy, work-integrated learning

## INTRODUCTION
The challenge for educators is to prepare students for the future of work where the fourth industrial revolution, characterized by innovation, automation, robotics, digitization and the internet of things, has made industries and occupations redundant (Schwab, 2017). At the same time, this revolution provides opportunities for workplaces and economies that can proactively embrace industrial transformation to achieve competitiveness and growth. In Australia, the *National Innovation and Science Agenda* has recognized the importance of innovation for global competitiveness, employment and growth (Australian Government, 2015). This sentiment is mirrored globally with countries including in Europe, North America and Asia embracing the need for innovation (Taks et al, 2014).

Innovation does not only pertain to scientific invention but it encompasses the entire process from idea generation, invention, technology development, manufacturing, marketing and commercialization to use by end consumers (Rampersad et al., 2015). Therefore, the applied scientist of the future is expected to move beyond predominantly technical skills and be equipped with a broad range of innovation skills. Within the science education literature, studies have begun to develop approaches to build innovation skills in students (Brent & Felder, 2014; Daly et al. 2014) through makerspaces (Halverson & Sheridan, 2014); the incorporation of technology innovation teaching and new venture creation into science programs (Standish-Koun & Rice, 2002); and innovative design (Daly et al., 2012).

Work integrated learning (WIL) is an important pedagogical tool in developing innovation skills as it prepares students for solving real life problems (Jiusto & Dibiasio, 2006). It fosters innovation as it facilitates the creation of new products and services (Groenewald, 2004; Rampersad, 2015). As it is highly immersive, it is deemed more effective compared to traditional approaches applied in entrepreneurship education involving presentations by entrepreneurs, case studies and business planning competitions (Rampersad, 2014).

This study focuses on the development of innovation skills among WIL students. While previous research was useful in examining the employability context (Billett, 2011; Billett et al., 2014), a greater investigation is needed on innovation. For instance, Bennett (2015) and Male et al. (2017) have contributed valuable perspectives on gender and self-identity against the backdrop of employability in the engineering profession, but more research is needed to incorporate the important focus on innovation.

Therefore, the research question of this study is 'What innovation skills are needed to improve employability?' It measures innovation skills before and after WIL placement to understand the extent to which students are developing such skills.

## KEY INNOVATION SKILLS

In understanding the development of innovation skills in WIL students, the study builds on previous quantitative work of Jackson (2013) which reflects typical skill requirements for new graduates and is also synonymous with the scholarly literature on employability skills in science, technology, engineering and mathematics (STEM) students (Male et al., 2017; Passow, 2012). The study adapts and extends measures of innovation skills so that they are applicable in the STEM context. It does so by building on previous qualitative work that confirmed relevant innovation skills in science students through WIL (Rampersad, 2015; Rampersad & Patel, 2014; Rampersad & Jarvis, 2012). The proposed project extends that qualitative research by developing quantitative measures and contributing a validated model for developing innovation skills for engineering WIL students. Quantitative measurement is important because it facilitates cross-sectoral comparisons and aids in monitoring changes in the skill level through time.

There is much rhetoric and anecdotes on the innovation skills needed for the jobs of the future, but there is little empirical evidence substantiating the key factors or determinants of such skills. The Foundation of Young Australians produced a report entitled *'The new basics: Big data reveals the skills young people need for the New Work Order'* where they suggested skills that Australian youth needs for jobs of the future for innovation include problem solving, critical thinking, communication and teamwork (FYA, 2016). These skills were identified as threshold (core) skills for science graduates in the definition of the Science threshold learning outcomes (TLOs) (Jones, Yates & Kelder, 2011). Since the Science TLOs were constructed through national consensus, Australian Faculties of Science have agreed that these skills are fundamental for a pass degree. However, these skills are yet to be empirically tested for their impact on innovation. Therefore, the impact of these skills on innovation will be examined in this study and are discussed further in this section.

**INNOVATION AND ENTERPRISE**: The teaching of innovation within science education should not only be geared towards generating entrepreneurs who start their own businesses but also intrapreneurs, that is, those who have an entrepreneurial mindset and can contribute to innovation within enterprises (Taks et al., 2014). For WIL students, their contributions towards the development of new products and services in businesses are important (Rampersad, 2015). In addition to entrepreneurship, intrapreneurship and new product and/or service development, Jackson et al. (2013) also include creativity and lateral thinking as important dimensions of innovation.

**PROBLEM SOLVING:** Problem solving is deemed central to STEM education as well as practice (McNeil et al., 2016; Woods et al, 1997). It can be defined as "an ability to analyze and transform information as a basis for making decisions and progress toward the solution of practical problems" (Hambur et al., 2002, p.2). STEM students perceive problem solving as vital for their future increasingly characterized by innovation (Kirn & Benson, 2018).

**CRITICAL THINKING**: Critical thinking refers to logical, analytical, conceptual, evaluative and reflective reasoning (Fowari, 2016). Yacoubian and Khishfe (2018) argue that it is a vital skills in science education. Graduate Careers Australia surveyed 271 Australian employers and revealed that critical thinking among the top three selection criteria used in the graduate recruitment process (GCA, 2014).

**COMMUNICATION**: Communication has emerged as an important factor influencing innovation. It refers to "the ability to use language, symbols and text interactively" (Rychen, 2002). It includes verbal and written communication and meeting participation (Jackson & Chapman, 2012). Within STEM education, it has been recognized as a critical factor for student success (Ford & Riley, 2003).

**TEAMWORK**: Teamwork is defined as "the ability to work constructively with others on a task" (Knight & Yorke, 2004, p. 8). A study undertaken by the National Collegiate Inventors and Innovators Alliance (NCIIA) in the United States, examined the impact of teamwork in entrepreneurial settings and found that teamwork training needs to be improved (Adams, 2001).

## METHOD

This quantitative study involved two data collection phases. The first phase, completed in August

2017, focused on **pre-placement baseline data collection**. It required students to complete a questionnaire on their perceived innovation and employability skills prior to embarking on their placements. Information Technology (31) and engineering (80) students enrolled in the WIL program at Flinders University, College of Science and Engineering were recruited for this research. 100 students were male while 11 were female: this gender imbalance reflecting the skew towards male students enrolled in the respective engineering and IT degrees in Australia (Male et al., 2017). The age of students also ranged from 19-21 years (40), 22-25 years (42) and 26+ years (29).

This WIL program uses project based learning whereby students undertake a project initiated by an industry partner. The duration of the placement is 12-20 weeks (full-time equivalent). The second research phase involved **post-placement data collection.** This phase occurred in February 2018 and required student to complete a self-assessment of their skill levels following completion of their placements. Completed responses were received from all 111 WIL students, both before and after their placements.

The questionnaire was completed online. Questions used in the questionnaire were derived and adapted from Jackson (2013) which stemmed from an extensive review of skills requirements in undergraduate students. Constructs in the questionnaire were operationalized using multi-item, 11-point Likert scales, which are straightforward and easy to administer (Kinnear et al., 1996). Furthermore, these scales were also suitable as the questionnaire served not only as a research instrument but as an assessment tool with a common frame of reference from 0-10, which could be easily interpreted by students. A multi-item scale is also justified over single item measures as it is more reliable and has less measurement error, distinctions can be made among respondents. It combines specific single measures, and thus, reflects more attributes of a construct (Churchill, 1979). Participants rated the level which best described their ability to perform each skill in the workplace pre- and post- placement.

## PRESENTATION AND INTERPRETATION OF FINDINGS

Data on student self-assessment of skills was analyzed before and after the placement period. Table 1 shows that on average, students expressed consistent significant increases in all skill categories. Innovation skills had the highest improvements (including 12% and 13%). This reflects the perceived development of innovation skills through the WIL process. However, other dimensions like influencing others, conflict resolution, innovation, entrepreneurship/intrapreneurship and lateral thinking /creativity scored lower implying that current curriculum does not sufficiently supports development of these skills. Interestingly enough these particular skills are essential for the future development of the innovation mindset. An alternative explanation is that the WIL experience changed student's ability to judge their own performance by providing new benchmarks. That is, the change in context affected the student's understanding of how a skill is demonstrated. Although employability scored the highest on the full scale, the overall increase is actually the lowest (only 5%). This could lead to the conclusion that innovation skills could be better nurtured within current curriculum in order produce more employable graduates.

**Table 1: Average student self-assessment before and after placement**

| **Factor** | **Dimension** | **Before Placement** | | | | **After Placement** | | | | **Change In Avg** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Avg** | **Min** | **Max** | **SD** | **Avg** | **Min** | **Max** | **SD** | |
| Problem Solving | Reasoning | 7.97 | 5 | 10 | 1.58 | 8.72 | 5 | 10 | 1.18 | **9%** |
| | Analysing and diagnosing | 7.86 | 5 | 10 | 1.51 | 8.75 | 5 | 10 | 1.25 | **11%** |
| | Decision making | 7.61 | 3 | 10 | 1.62 | 8.41 | 5 | 10 | 1.28 | **10%** |
| Critical Thinking | Conceptualization | 7.78 | 5 | 10 | 1.50 | 8.63 | 5 | 10 | 1.19 | **11%** |
| | Evaluation | 7.66 | 4 | 10 | 1.52 | 8.41 | 5 | 10 | 1.17 | **10%** |
| Communication | Verbal communication | 7.90 | 3 | 10 | 1.69 | 8.55 | 5 | 10 | 1.28 | **8%** |
| | Giving and receiving feedback | 7.70 | 5 | 10 | 1.56 | 8.46 | 3 | 10 | 1.31 | **10%** |
| | Meeting participation | 7.61 | 3 | 10 | 1.78 | 8.39 | 4 | 10 | 1.47 | **10%** |
| | Written communication | 7.84 | 3 | 10 | 1.70 | 8.43 | 4 | 10 | 1.32 | **8%** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Teamwork | Task collaboration | 8.11 | 2 | 10 | 1.66 | 8.77 | 5 | 10 | 1.14 | **8%** |
| | Social intelligence | 7.91 | 3 | 10 | 1.69 | 8.59 | 5 | 10 | 1.15 | **9%** |
| | Influencing others | 7.20 | 4 | 10 | 1.65 | 8.00 | 4 | 10 | 1.39 | **11%** |
| | Conflict resolution | 7.31 | 1 | 10 | 1.84 | 8.08 | 5 | 10 | 1.42 | **11%** |
| Innovation | Innovation | 7.18 | 2 | 10 | 1.72 | 8.14 | 4 | 10 | 1.76 | **13%** |
| | Entrepreneurship/Intrapreneurship | 7.11 | 4 | 10 | 1.70 | 7.99 | 3 | 10 | 1.41 | **12%** |
| | Lateral thinking/creativity | 7.47 | 3 | 10 | 1.68 | 8.22 | 2 | 10 | 1.48 | **10%** |
| Employability | How employable am I? | 8.67 | 5 | 10 | 1.73 | 9.04 | 4 | 10 | 1.20 | **5%** |

Feedback was provided to each student to demonstrate changes in their perceived skill levels before and after their placements through a spider diagram as shown in Figure 1. They were also provided with a spreadsheet of their raw data pre- and post-placement and asked to complete a reflection on any changes (similar to Table 1). This data shed light on the differential observed between the development of different skills.

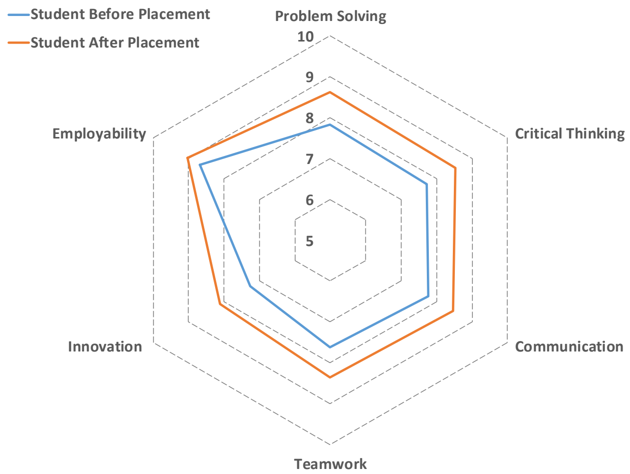


**Figure 1: Self-assessment feedback to students**

## CONCLUSIONS AND IMPLICATIONS FOR EDUCATORS

The study examined students' transferable skills pre- and post- placement. It focused on factors including problem solving, critical thinking, communication, teamwork, innovation and employability. The analysis confirmed consistent increases in all skills across all categories and their associated dimensions, thereby reflecting the effectiveness of WIL in overall skill development. The study uncovered key strengths of students including reasoning, analyzing and diagnosing, conceptualization, task collaboration and social intelligence (as detailed in Table 1). However, influencing others, conflict resolution and innovation including entrepreneurship/intrapreneurship and lateral thinking/creativity were dimensions of marginal comparative weaknesses, despite the fact that innovation scored the highest increase of 13% compared to all other skill categories. This implies that the current curriculum does not sufficiently support the development of these skills. These particular skills are essential for innovation and future employability of new graduates. As pre-placement scores for innovation were low, it indicated that there is a lack of innovation education in earlier phases of the curricula. Prior studies undertaken by Jackson (2012) was conducted among non-STEM students such as Business students. Therefore, this study was useful in shining a spotlight on the STEM curriculum in particular.

While the pedagogical process of WIL was instrumental in nurturing innovation skills, evidenced by the largest increase in such skills through the process compared to others (Table 1), more may be needed. The whole of the degree needs to be enhanced to include the development innovation skills throughout the program. The study has confirmed that existing programs equip students with strengths in problem solving, critical thinking and also generally in team work and communication. However, more is needed to build other essential innovation skills. For instance, to nurture entrepreneurship skills, students should be exposed to exploring the commercial viability of technical solutions that they develop. They should be coached to understand who the consumers are for their inventions, the size of the market and the opportunity, how to effectively partner with stakeholders to get the invention to the market and whether the invention will be profitable.

As intrapreneurship is also important, one approach can be for educators to foster relationships with industry partners to develop innovation challenges within teaching programs focused on solving real-life problems for industry and new product or service development. Industry partners should be recruited as mentors to provide feedback to students, thereby being mutually beneficial to students and businesses. Students are most stimulated by authentic education with relevant material. Educators and industry mentors should possess awareness of the industry and its problems that need to be solved so that the material is well integrated within the broader curriculum.

To develop skills on conflict resolution and the ability to influence others, multi-disciplinary teams should be corralled to facilitate the generation of different perspectives, creative conflicts and robust solutions. Students should be taught to develop persuasive pitches through effective narratives and storytelling to convince others of their ideas, negotiate and build partnerships.

By engaging students in self-reflecting practice, they are equipped with insights into their learning process, thereby boosting their awareness and supporting the development of their innovation and employability skills.

Future research can also use the questionnaire to ascertain views from industry partners and teaching staff on the skill level of students following their placement. Multiple views can be used to triangulate findings and also identify areas where there are discrepancies on the attainment of skills to ensure that preparation programs can be fine-tuned to foster clear communication around expectations and understandings of various skills.

The future of work is complex and uncertain. However, by nurturing the innovation skills in students not only through effective WIL units but also through the whole of degree, graduates will be better prepared for the workforce of tomorrow.

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# APPENDIX: QUESTIONNAIRE

This survey should be completed prior commencement and upon completion of your placement. Please think your about ability to demonstrate particular skills. Please highlight your answer on a scale of 0 -10 (0= strongly disagree and 10=strongly agree) concerning your ability to demonstrate specific skills.

| Factor | Measurement item | Scale |
|---|---|---|
| **Problem solving** | *Reasoning:* Use rational and logical reasoning to deduce appropriate and well-reasoned conclusions. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Analyzing and diagnosing:* Analyze facts and circumstances and ask the right questions to diagnose problems. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Decision making:* Make appropriate and timely decisions, in light of available information, in sensitive and complex situations. | 0 1 2 3 4 5 6 7 8 9 10 |
| **Critical thinking** | *Conceptualisation:* Recognise patterns in detailed documents and scenarios to understand the ‘bigger’ picture. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Evaluation:* Recognise, evaluate and retain key points in a range of documents and scenarios. | 0 1 2 3 4 5 6 7 8 9 10 |
| **Communication** | *Verbal communication:* Communicate orally in a clear and sensitive manner which is appropriately varied according to different audiences and seniority levels. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Giving and receiving feedback:* Give and receive feedback appropriately and constructively. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Meeting participation:* Participate constructively in meetings. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Written communication:* Present knowledge, in a range of written formats, in a professional, structured and clear manner. | 0 1 2 3 4 5 6 7 8 9 10 |
| **Teamwork** | *Task collaboration:* Complete group tasks through collaborative communication, problem solving, discussion and planning. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Social intelligence:* Acknowledge the complex emotions and viewpoints of others and respond sensitively and appropriately. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Influencing others:* Defend and assert their rights, interests and needs and convince others of the validity of one’s point of view. | 0 1 2 3 4 5 6 7 8 9 10 |
| | *Conflict resolution:* Address and resolve contentious issues with key stakeholders. | 0 1 2 3 4 5 6 7 8 9 10 |
| **Innovation** | Innovation: Contribute towards the development of new products, services or technologies (e.g. software, applications, devices). | 0 1 2 3 4 5 6 7 8 9 10 |
| | Entrepreneurship/ Intrapreneurship: Initiate change and add value by embracing new ideas and showing ingenuity and creativity in addressing challenges and problems. | 0 1 2 3 4 5 6 7 8 9 10 |
| | Lateral thinking/ creativity: Develop a range of solutions using lateral and creative thinking. | 0 1 2 3 4 5 6 7 8 9 10 |

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