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# Robot will take your job: Innovation for an era of artificial intelligence

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ABSTRACT

Fear is growing that robots and artificial intelligence will replace many occupations. To remain relevant in this changing career landscape, the worker of the future is expected to be innovative, able to spot opportunities transform industries and provide creative solutions to meet global challenges. To develop such capabilities, work integrated learning (WIL) has emerged as an important approach. The purpose of this study is to investigate the key factors driving innovation among WIL students. Unlike prior studies that have been predominantly qualitative or based on one single snapshot, this quantitative, longitudinal study measures student capabilities before and after participation in a WIL placement at a business. It then undertakes confirmatory factor analysis to compare pre- and post-placement capabilities. The study found that critical thinking, problem solving, communication and teamwork have significant impacts on the development of innovation: vital in the era of artificial intelligence.

## 1. Introduction

There is universal recognition for the need for innovation to transform economies (Atwood et al. 2016; Castaño, Méndez, & Galindo, 2016; Jenson, Leith, Doyle, West, & Miles, 2016a; Jenson, Leith, Doyle, West, & Miles, 2016b; Xie & Wang, 2020). With, the advent to industry 4.0 or the fourth industrial revolution characterized by cyber-physical systems, there is a focus on the innovative application of advanced robotics and artificial intelligence to bring about digital transformation in businesses (Haenein & Kaplan, 2019; Kaplan & Haeniein, 2019; Srivarajah et al., 2017). However, reaping the benefits of industry 4.0 is not just a technological challenge but also a human issue, requiring attention being placed on upskilling and also the human dimensions of major change (Berger, von Briel, Davidsson, & Kuckertz, 2019). Consequently, human factors are critical elements of industry 4.0 skills needed for the future, to not only ensure that workers can effectively and confidently use the new technologies but also that they survive and thrive in a quickly changing workplace (AGE, 2015; Sousa & Rocha, 2019). While robotics such as collaborative robots (cobots) can assist workers and improve their safety and productivity, if the skill transition is not effectively managed, many fear that robots will take away their jobs.

Creative problem solvers are essential in revolutionizing industries, stimulating economies and engineering solutions to address the challenges facing the environment, energy, food, water and security. This sentiment is also mirrored widely throughout Europe as reflected in a number of pertinent reports by the European Commission (2006); the Higher Education and Training Council (2012); and the UK Quality Assurance Agency for Higher Education (2012). In the United States, there are calls among political leaders for innovative engineers to drive the American economy (Attwood et al., 2016). The Australian government has also placed increased attention on the need for innovation education (Office of the Chief Scientist, 2015; National Innovation and Science Agenda, 2016).

In addition to the practitioner sphere, innovation has attracted increased attention in the scholarly literature (Atwood et al. 2016; Taks, Tynjala, Toding, Kukemelk, & Venesaar, 2014). Studies have begun to characterize systematic approaches that develop creativity in students (Brent & Felder, 2014; Daly, Mosyjowski, & Seifert, 2014); promote makerspaces to foster new ideas (Halverson & Sheridan, 2014); incorporate technology innovation teaching and new venture creation (Jackson, Gordon, & Christholm, 1996; Standish-Koun & Rice, 2002; Taks et al., 2014); and focus on innovative design (Daly, Yilmaz, Christian, Seifert, & Gonzalez, 2012). The teaching of entrepreneurship 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 firms (Taks et al., 2014).

Initiatives that focus on the teaching of innovation have also focused on the development of generic skills as important in driving innovation (Taks et al., 2014), albeit further empirical research is needed to examine the effectiveness of particular pedagogical approaches.

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These generic skills have been otherwise termed professional (Shuman, Besterfield-Sacre, & McGourty, 2005); employability or transferable skills. To negotiate the challenges of work in the future characterized by increased automation, advanced robotics, artificial intelligence, rapid change and industry transformation, Taks et al. (2014, p. 573) argue that the next generation of workers need to be well equipped with not only deep knowledge but various skills in problem solving, critical thinking, communication and teamwork, as well as innovation and enterprise. Such employability skills have attracted attention in many countries including the United States through the Spellings Commissions report (Spellings, 2006), the United Kingdom in the Dearing Report (National Committee of Inquiry, 1997) and Australia in the Bradley Review (Bradley, Noonan, Nugent, & Scales, 2008).

Experiential learning is an important pedagogical tool in driving innovation (Jiusto & Dibiasio, 2006; Taks et al., 2014). Otherwise termed work integrated learning (WIL) (Rampersad, 2015), cooperative education (Groenewald, 2004), industry partnered active learning (Lamansusa et al., 2008) or professional development program (Gonzalez-Quevedo, Mercado-Sherman, Kruckemeyer, & Wilson, 2000), WIL prepares students for solving real life problems. It fosters innovation as it facilitates the creation of new products and services. As WIL 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 makes an important theoretical contribution by providing empirical evidence for the impact of drivers of innovation through work integrated learning, by quantitatively measuring pre and post placement scores on skills through student self-reflection. Past research has predominantly investigated perspectives of university educators (Billett, Bennett, Jollands, & Kinash., & S., Lee, N. , 2014; Jackson & Chapman, 2012) or have generally been based on qualitative research (Daly et al., 2014; Rampersad & Jarvis, 2012). Furthermore, while previous research has examined the employability context (Chan, Zhao, & Luk, 2017), such research has not included a focus on innovation. For instance, Bennett et al. (2015) and Male (2017) have contributed valuable perspectives on gender and self-identity against the backdrop of employability, but more research is needed to incorporate the important focus on innovation. Furthermore, there has been limited longitudinal studies that have measured skill levels at different points of the educational process to gauge the development or change in skills.

Therefore, the research question of this study is 'What are the key factors influencing the development of innovation in students through WIL?' It will measure innovation and potential drivers before the after the WIL placement. Findings of the study are important in (1) offering feedback on career literacy to students on the development of innovation; (2) enhancing WIL program development by uncovering areas of skill deficiency which can then be used to inform corrective action in subsequent WIL preparation programs and offer further support to students; and (3) informing industry engagement efforts to WIL hosts through evidence-based communication on the capabilities and benefits of WIL students.

## 2. Drivers of innovation

Innovation refers to 'the process of bringing into being something novel and useful' (Sternberg & O'Hara, 1999, p. 251). Traditionally, innovation was viewed as a fluid, whimsical process that was associated with an innate trait of individuals. More recently, it is seen as a team-based, teachable and learnable process (McWilliam & Dawson, 2008; Rampersad, 2014). It involves the full spectrum of activities from creative thinking and idea generation to the development and commercialization of new products that offer benefits to end users. While innovation can range from incremental improvements to radical, transformative game changers, the degree of innovation may be relative to the eye of the beholder. For example, researchers working on a technology for many years may deem a particular innovation as incremental, for instance long-life battery storage for electric cars, whereas the same innovation may be viewed as radical to consumers if they have not been previously exposed to it. Furthermore, innovation can be viewed as adaptations of what currently exists. Technologies used in specific contexts can be transferred to different industries, with significant impact. For instance, rotating paint application technology can be used in crop pesticide applications and even air-conditioning units to improve the efficiency of engineering design.

In understanding the development of innovation for WIL students, the study builds on previous quantitative work of Jackson (2013) which reflects typical skill requirements for new graduates and are also synonymous with global generic skills and the scholarly literature on employability skills (Male et al, 2009; Passow, 2012; Scott & Yates, 2002). This study investigates how these skills drive innovation. It does so by building on previous qualitative work that confirmed relevant innovation measures through WIL (Rampersad, 2015; Rampersad & Patel, 2014; Rampersad & Jarvis, 2012). The proposed project extends that qualitative research by developing quantitative measures and contributes a validated model for developing innovation. 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 skills needed for the jobs of the future, but there is little empirical evidence substantiating what are the key factors or determinants of innovation. 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 youths need for jobs of the future, including problem solving, critical thinking, communication and teamwork (FYA, 2016). 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 discussed further in this section.

### 2.1. Problem solving

Problem solving is deemed central to skills for the future of work (McNeil et al., 2016; Woods et al., 1997). It can be defined as "*an ability to analyse and transform information as a basis for making decisions and progress towards the solution of practical problems*" (Hambur, S., Rowe, K., Tu Luc, L., Australian Council for Educational Research (2002), 2002, p.2). Understanding and defining the business problem to be solved has been at the heart of successful collaboration between university and business (Rampersad, 2015). Additionally, in a technical sense, problem solving is central to engineering practice and education and is embedded in foundation courses such as Engineering Design (McNeil et al., 2016). Similarly, within Design education, problem solving is the basis of design thinking, a core element of that discipline. To elevate this learning and outcomes for end users, industry-based learning through WIL can be a powerful tool for innovation.

In this vein, problem solving is deemed a critical area of need for their future increasingly characterized by innovation (Kirn & Benson, 2018). For the next generation, problem solving has been deemed an essential knowledge area in developing the future worker who needs to be innovative and develop solutions for 'global technological, economic and societal challenges of the 21st century' (Redish & Smith, 2008, p. 296). Montag-Smit and Maertz (2017) analyse the impact of creative problem solving on innovation and found that factual information has a direct impact on innovation while range information had an indirect impact. However, it was a cross-sectional study and further longitudinal research would assist in exploring the impact of problem solving on the development of innovation. Therefore, we hypothesize the following:

*Hypothesis 1: Problem solving positively influences innovation*

### 2.2. Critical thinking

Critical thinking refers to logical, analytical, conceptual and reflective reasoning (Hager & Holland, 2006). Within the innovation context, many new startups fail due to the inherent risks involved and critical thinking is deemed essential in entrepreneurship education (Huq & Gilbert, 2017). As such, the application of critical thinking to de-risk initiatives and weigh up various courses of action is vital for successful innovation. Venture capitalists and other investors typically require this critical thinking to ensure a return on their investments by critiquing the market and business opportunity, identification of prospective consumers, partners and financial scenarios to foster successful innovation.

Despite the importance of this skill, Phillips and Bond (2004) argue that there is a worldwide skill deficiency in critical thinking despite being the most important aim of higher education. Graduate Careers Australia (GCA, 2007) surveyed 271 Australian employers and revealed that critical thinking is the 2nd top selection criteria used in the graduate recruitment process, while DETYA (2000) ranked it the 3rd out of 25 skills and competencies required by employers. Consequently, we propose the following hypothesis:

*Hypothesis 2: Critical thinking positively influences innovation*

### 2.3. Communication

Communication has emerged as an important factor influencing innovation. Montag-Smit and Maertz (2017) found that providing appropriate information during idea generation can improve innovation outcomes. Communication has a strong theoretical background in innovation network literature, where dimensions of transparency, credibility and codification or understanding are all necessary in bringing about successful innovation (Moenaert, Caeldries, Lievens, & Wauters, 2000).

Communication refers to "*the ability to use language, symbols and text interactively*" (Rychen, 2002). It includes verbal and written communication as well as meeting participation (Jackson & Chapman, 2012). Communication has been recognized as a critical factor for student success (Ford & Riley, 2003). Wilkins, Bernstein, and Bekki (2015) applied a communication skills assessment tool. However, data collection focused on female doctoral Science, Technology Engineering and Mathematics (STEM) students rather than undergraduate students. Further research is needed to quantitatively evaluate the impact of communication on innovation. Therefore, we hypothesize the following:

*Hypothesis 3: Communication positively influences innovation*

### 2.4. Teamwork

There is a large body of literature on innovation networks that feature the important role of relationships and interaction for successful innovation (Moller & Halinen, 2017; Lazzaretti & Capone, 2016). Similarly, within the educational setting, teamwork or interpersonal connections is needed for innovation.

Teamwork is defined as "*the ability to work constructively with others on a task*" (Knight & Yorke, 2004, p. 8). Yang and Han (2019) found that the amount of interaction has a positive impact on the number of ideas implemented. A study undertaken by the National Collegiate Inventors and Innovators Alliance (NCIIA), now 'VentureWell', in the United States, examined the impact of teamwork in entrepreneurial settings involving engineering students and found that teamwork training needs to be improved (Adams, 2001). Consequently, we propose the following hypothesis:

*Hypothesis 4: Teamwork positively influences innovation*

**Table 1**
Descriptive data on respondents.

| Category | Group/Sub-Group | Respondents | |
|---|---|---|---|
| | | *n* | % |
| Age Group | 19–21 years | 40 | 36.0 |
| | 22–25 years | 42 | 37.8 |
| | 26 + years | 29 | 26.1 |
| Gender | Female | 11 | 9.9 |
| | Male | 100 | 90.1 |
| | Other | 0 | 0 |
| Placement Duration | 450 h (12 weeks Full-time) | 31 | 27.9 |
| | 750 h (20 weeks Full-time) | 80 | 72.1 |
| Organization Size | Small (1–49 employees) | 38 | 34.2 |
| | Medium (50 – 149 employees) | 14 | 12.6 |
| | Large (150 + employees) | 59 | 53.2 |

## 3. Method

A quantitative approach was deemed suitable for this study to determine key factors associated with innovation in WIL students. Students were asked to complete a questionnaire to comment on their level pf innovation and its drivers. Undergraduate students enrolled in the WIL program at a mid-sized university in Australia were recruited for this research. The program under investigation provides placements of 12–20 weeks (full-time equivalent). The nature of placements in this program involves project-based-learning in collaboration with industry, whereby students complete a project of value and negotiated with an industry partner. Table 1 provides descriptive data on respondents.

All 111 students participating in the WIL program completed the questionnaire, both before and after their placement. The pre-placement questionnaire was administered in July 2017 and the post-placement questionnaire was administered in February 2018. Both questionnaires were sent to students via email and completed online. Questions included were based upon and adapted from Jackson (2013) which stemmed from an extensive review of studies on skills requirements in undergraduates (Jackson, , 2010) and innovation measures were adapted using conceptualizations of innovation stemming from the literature (Rampersad, 2015; Rampersad & Patel, 2014; Rampersad & Jarvis, 2012). Constructs in the questionnaire were operationalized using multi-item, 11- point Likert scales, which are straightforward and easy to administer while also capturing sufficient nuances in responses (Kinnear, Taylor, Johnson, & Armstrong, 1993). A multi-item scale is also justified over single item measures as it is more reliable and has less measurement error. Additionally, distinctions can be made among respondents and it combines specific single measures, and thus, reflects more attributes of a construct (Churchill, 1979).

Data analysis was conducted using the software packages SPSS and AMOS, employing confirmatory factor analysis. Various steps were taken in the analysis following Blunch (2007). First, data was screened using checks for normality. Second, constructs were assessed for reliability and validity. Third, confirmatory factor analysis and hypothesis testing was undertaken to evaluate the significance of each factor. The results of these steps will be explained next.

## 4. Results

### 4.1. Data preparation and screening

Before data was analyzed, it had to be screened. There was no missing data as respondents had to complete all questions in order to submit the survey online. However, normality was evaluated as is it important for distributions of data to exhibit this trait to facilitate unbiased and consistent models (Anderson & Gerbing, 1988). Normality was tested using checks for skewness and kurtosis. Skewness pertains to the symmetry while kurtosis refers to the peakedness of distributions

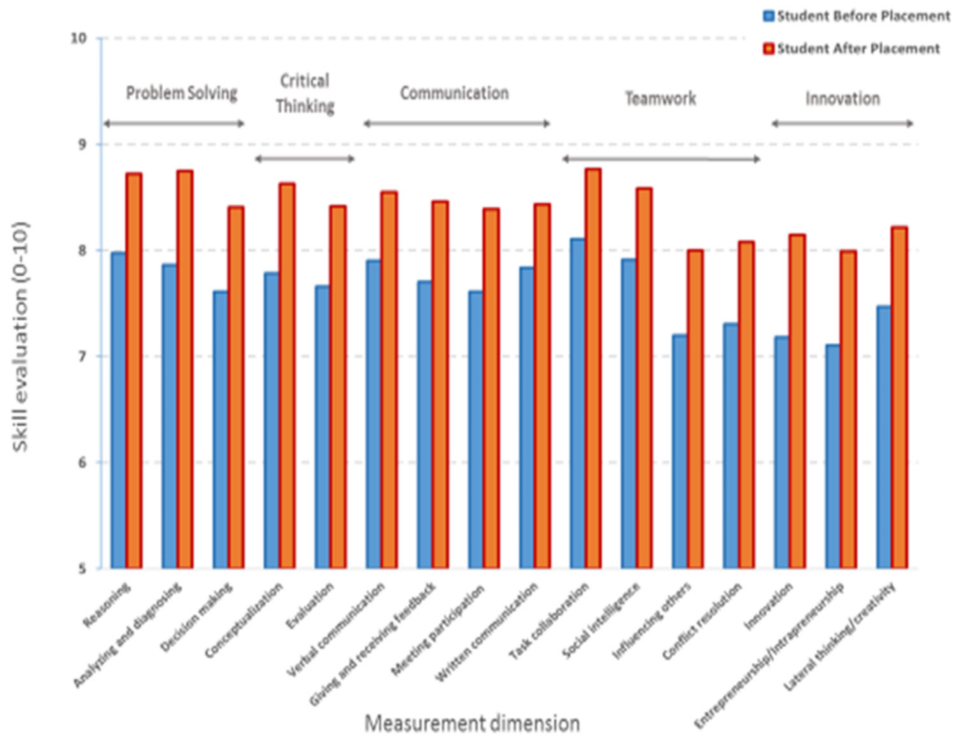


**Fig. 1.** Pre- post-placement skills comparison.

(Hair, Anderson, Tatham, & Black, 2006). The data in this study exhibited acceptable levels of skewness (ranging from −0.002 to −1.135) and kurtosis (ranging from 0.046 to 2.107) which were well below the maximum acceptable levels of 2 and 7 for these two tests (West, Finch, & Curran, 1995).

### 4.2. Descriptive analysis: Pre-placement and Post-placement comparison

Fig. 1 and Table 2 present average scores of skills from students prior to their placements and compares it with post placement data. It clearly shows that there has been a development in all skills following the placement.

Several steps were taken to avoid common method bias as addressing this is important in improving the validity and reliability of measures. First, different respondents were used including those undertaking placement at public and others at private organizations as shown in Table 2. Furthermore, data was collected at different times, before and after placement. Temporal separation of responses is need as an effective procedural strategy to reduce common methods bias (Garg, 2019).

To test for common method bias statistically, Harman's single factor score was used. Total variance for each factor was less than 50% therefore confirming that common method bias did not affect the data (Podsakoff, MacKenzie, & Podsakoff, 2012). Furthermore, a marker variable test was also used with a result of less than 1%, therefore demonstrating that common method bias was not a problem (Jacobsen & Jensen, 2015).

Additionally, Pearson r correlation coefficients were calculated to examine the relationship between the dependent variables and innovation. The correlation coefficient for the relationship between innovation and problem solving was 0.6287, critical thinking was 0.5215, communication 0.6301 and teamwork was 0.5752. These values all represent a moderate positive correlation, reflecting that the tendency is high for each independent variable score to be aligned with a high innovation score.

### 4.3. Reliability and validity of measures

Once the data was screened, checks for the reliability and validity of our constructs were then undertaken. Reliability refers to the level of consistency and precision of measurement while validity pertains to the level of accuracy with which the scale represents and measures the variable intended (Nunnally, 1970). Table 3 provides details of the reliability and validity of our constructs.

Reliability was evaluated using coefficient alpha in SPSS 23.0. Coefficient alpha demonstrated acceptable reliability and values ranged from 0.785 to 0.937 for all constructs, which exceeded the minimum acceptable value of 0.7 (Kline, 2005). Construct reliabilities were also calculated using data outputted from AMOS 23.0 on standardized item loadings and error measurement (Kline, 2005). Values for construct reliability for the factors ranged from 0.719 to 0.982 exceeding the minimum threshold of 0.7 (Hair et al., 2006).

Discriminant validity was also assessed. This is a measure of the novelty or distinctiveness of each item (Churchill, 1979). All items had appropriate discriminant validity as they exceeded the lower threshold of 0.5 (Moon & Kim, 2001) as shown in Table 4.

### 4.4. Hypothesis testing

After scales were evaluated, confirmatory factors analysis and hypothesis testing were undertaken. The data is the two phases – pre and post placement were analyzed separately. As shown in Table 5, all hypotheses were supported. As a result, the study provides empirical evidence for the impact of problem solving, critical thinking, communication and teamwork on innovation. The supported model is also illustrated in Fig. 2.

## 5. Conclusion

This study examined key factors influencing the development of innovation by undertaking pre- and post-placement measurement. In particular, it provided evidence for the importance of problem solving,

**Table 2**
Measurement items and pre- post- placement comparison (public and private organizations).

| Factor | Dimension | Measure | Student score before placement | | Student score after placement | |
|---|---|---|---|---|---|---|
| | | | Private | Public | Private | Public |
| Problem Solving | Reasoning | Use rational and logical reasoning to deduce appropriate and well-reasoned conclusions. | 7.97 | 7.94 | 8.72 | 8.70 |
| | Analyzing and diagnosing | Analyze facts and circumstances and ask the right questions to diagnose problems. | 7.86 | 7.83 | 8.75 | 8.72 |
| | Decision making | Make appropriate and timely decisions, in light of available information, in sensitive and complex situations. | 7.61 | 7.58 | 8.41 | 8.39 |
| Critical Thinking | Conceptualization | Recognize patterns in detailed documents and scenarios to understand the 'bigger' picture. | 7.78 | 7.74 | 8.63 | 8.61 |
| | Evaluation | Recognize, evaluate and retain key points in a range of documents and scenarios. | 7.66 | 7.61 | 8.41 | 8.39 |
| Communication | Verbal communication | Communicate orally in a clear and sensitive manner which is appropriately varied according to different audiences and seniority levels. | 7.90 | 7.87 | 8.55 | 8.52 |
| | Giving and receiving feedback | Give and receive feedback appropriately and constructively. | 7.70 | 7.69 | 8.46 | 8.44 |
| | Meeting participation | Participate constructively in meetings. | 7.61 | 7.57 | 8.39 | 8.36 |
| | Written communication | Present knowledge, in a range of written formats, in a professional, structured and clear manner. | 7.84 | 7.81 | 8.43 | 8.40 |
| Teamwork | Task collaboration | Complete group tasks through collaborative communication, problem solving, discussion and planning. | 8.11 | 8.11 | 8.77 | 8.74 |
| | Social intelligence | Acknowledge the complex emotions and viewpoints of others and respond sensitively and appropriately. | 7.91 | 7.92 | 8.59 | 8.56 |
| | Influencing others | Defend and assert their rights, interests and needs and convince others of the validity of one's point of view. | 7.20 | 7.17 | 8.00 | 7.98 |
| | Conflict resolution | Address and resolve contentious issues with key stakeholders. | 7.31 | 7.28 | 8.08 | 8.05 |
| Innovation | Innovation | Contribute towards the development of new products, services or technologies (e.g. software, applications, devices). | 7.18 | 7.14 | 8.14 | 8.11 |
| | Entrepreneurship/ Intrapreneurship | Initiate change and add value by embracing new ideas and showing ingenuity and creativity in addressing challenges and problems. | 7.11 | 7.06 | 7.99 | 7.97 |
| | Lateral thinking/ creativity | Develop a range of solutions using lateral and creative thinking. | 7.47 | 7.43 | 8.22 | 8.18 |

**Table 3**
Reliability and Validity of Constructs.

| Construct | Coefficient Alpha (> 0.7) | | Construct Reliability (> 0.7) | |
|---|---|---|---|---|
| | Pre-placement | Post-placement | Pre-placement | Post-placement |
| Problem Solving | 0.937 | 0.905 | 0.863 | 0.935 |
| Critical Thinking | 0.925 | 0.871 | 0.899 | 0.943 |
| Communication | 0.876 | 0.785 | 0.719 | 0.913 |
| Teamwork | 0.853 | 0.816 | 0.801 | 0.862 |
| Innovation | 0.911 | 0.831 | 0.804 | 0.982 |

**Table 4**
Factor item loadings and descriptive statistics.

| Factor | Dimension | Loading | Mean | Standard deviation |
|---|---|---|---|---|
| Problem Solving | Reasoning | 0.793 | 8.721 | 1.185 |
| | Analyzing and diagnosing | 0.899 | 8.748 | 1.247 |
| | Decision making | 0.624 | 8.405 | 1.282 |
| Critical Thinking | Conceptualization | 0.931 | 8.631 | 1.190 |
| | Evaluation | 0.952 | 8.414 | 1.171 |
| Communication | Verbal communication | 0.846 | 8.550 | 1.277 |
| | Giving and receiving feedback | 0.543 | 8.459 | 1.306 |
| | Meeting participation | 0.614 | 8.387 | 1.466 |
| | Written communication | 0.652 | 8.432 | 1.319 |
| Teamwork | Task collaboration | 0.576 | 8.766 | 1.136 |
| | Social intelligence | 0.767 | 8.586 | 1.148 |
| | Influencing others | 0.743 | 8.000 | 1.395 |
| | Conflict resolution | 0.581 | 8.081 | 1.415 |
| Innovation | Innovation | 0.628 | 8.144 | 1.757 |
| | Entrepreneurship/ Intrapreneurship | 1.008 | 7.991 | 1.411 |
| | Lateral thinking/ creativity | 0.677 | 8.216 | 1.480 |

critical thinking, communication and teamwork in driving innovation. Unlike prior studies that have been predominantly qualitative or based on one single snapshot, this longitudinal study undertook quantitative analysis at two stages of the educational process: before and after a WIL placement.

A key outcome of this study has been a validated tool that quantitatively measures the development of innovation and its drivers. Results from this tool can feed back into WIL program development to enhance student preparation and support for skill development. It will also be useful in offering feedback to students on their career literacy, self-awareness and empowerment for their development.

The study offers a range of useful implications. Evaluating skill levels in WIL students helps educators in determining areas of skill deficiency which can then be used to inform corrective action in subsequent WIL preparation programs and offer further support to students. In addition, it reveals the strong skills that students demonstrate through participation in the WIL program which can then be used for evidence-based promotion and expansion of the WIL program to future hosts. For students, the experience of engaging in self-reflection pre- and post-placement through the questionnaire will enhance participants' insights into their own skill development, therefore boosting their awareness and development of innovation.

The study is not without limitations and provides opportunities for future research. Future research can include a focus on the impact on artificial intelligence within the framework, experimenting with artificial intelligence (AI) versus humans. This would investigate the nuances of the impact of AI and big data on innovation given contradictory prior research. Recent research has contrasted to prevailing view of the prolific impact of big data on innovation (Akter, Wamba, Gunasekaran, Dubey, & Childe, 2016; Gooble, 2013) as it found that big data is not necessarily better, with the data volume not leading to improved innovation performance (Ghasemaghaei & Calic, 2020). Second,

**Table 5**
Hypothesis Support.

| Hypothesis | Independent Variable | Dependent Variable | P-Value (Pre) | Support | P-Value (Post) | Support |
|---|---|---|---|---|---|---|
| 1 | Problem solving | Innovation | *** | Yes | *** | Yes |
| 2 | Critical thinking | Innovation | *** | Yes | *** | Yes |
| 3 | Communication | Innovation | *** | Yes | *** | Yes |
| 4 | Teamwork | Innovation | *** | Yes | *** | Yes |

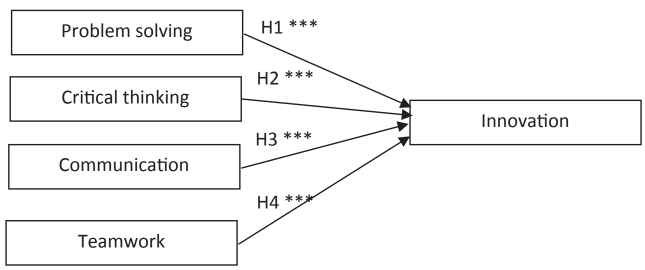


**Fig. 2.** Model for driving innovation.

employing the tool beyond WIL and incorporating it at various stages of an educational program – at the start, middle and end may help students to take charge of their development through the course of the studies. Third, results from the tool can be used to compare various engineering cohorts to determine whether certain programs have strengths or weaknesses that should be addressed. Third, the tool can be used through time to track program development and monitor the effectiveness of programs. Indeed, this study is an important first step in validating the tool which can form the basis of subsequent studies.

For industry and a community looking for innovative solutions to address challenges facing the areas of health, food, environment, manufacturing and the economy, the interaction of talented students with industries and businesses will prove highly beneficial. The well-researched and well-developed tool to measure the development of innovation provided by this study can be applied to enhance collaboration and innovation between university and industry. In an era increasingly characterized by artificial intelligence, rather than fearing the robot, attention is needed on equipping the workforce with innovation skills needed for the future of work.

## References


Adams, S. G. (2001). The Effectiveness of the E-Team Approach to Invention and Innovation. *Journal of Engineering Education, 90*(4), 597–600. https://doi.org/10.1002/j.2168-9830.2001.tb00645.x.

AGE (2015). *Association of German Engineers. Industry 4.0, A Discussion of Qualifications and Skills in the Factory of the Future: A German and.* American Perspective.

Akter, S., Wamba, S. F., Gunasekaran, A., Dubey, R., & Childe, S. J. (2016). How to improve firm performance using big data analytics capability and business strategy alignment? *International Journal of Production Economics, 182*, 113–131. https://doi.org/10.1016/j.ijpe.2016.08.018.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411.

Atwood, S. A., & Pretz, J. E. (2016). Creativity as a Factor in Persistence and Academic Achievement of Engineering Undergraduates. *Journal of Engineering Education. 105*(4), 540–559. https://doi.org/10.1002/jee.20130.

Bennett, D., Figueroa, E., Gardner, A., & Khan, N. (2015). *Gender inclusivity of engineering students' experiences of workplace learning.* Office of Teaching and Learning Report: Australian Government.

Berger, E. S., von Briel, F., Davidsson, P., & Kuckertz, A. (2019). Digital or not–The future of entrepreneurship and innovation: Introduction to the special issue. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2019.12.020.

Billett, S., Bennett, D., Jollands, M., Kinash., & S., Lee, N. (2014). Graduate employability and productivity. Learning and Teaching for our times: Higher education in a digital era. Sydney, Australia.

Blunch, N. (2007). *Introduction to sructural equation modelling using SPSS and AMOS.* Los Angeles, London, New Dehli, Singapore: Sage.

Bradley, D., Noonan, P., Nugent, H., & Scales, B. (2008). *Review of Australian higher education.* Canberra, Australia: Department of Education, Employment and Workplace Relations, Australian Government.

Brent, R., & Felder, R. M. (2014). Want your students to think creatively and critically? How about teaching them? *Chemical Engineering Education, 48*(2), 113–114.

Castaño, M. S., Méndez, M. T., & Galindo, M.Á. (2016). The effect of public policies on entrepreneurial activity and economic growth. *Journal of Business Research, 69*(11), 5280–5285. https://doi.org/10.1016/j.jbusres.2016.04.125.

Chan, C. K., Zhao, Y., & Luk, L. Y. (2017). A validated and reliable instrument investigating engineering students' perceptions of competency in generic skills. *Journal of Engineering Education, 106*(2), 299–325.

Churchill, G. A., Jr (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research, 16*(1), 64–73. https://doi.org/10.1177/002224377901600110.

Daly, S. R., Mosyjowski, E. A., & Seifert, C. M. (2014). Teaching creativity in engineering courses. *Journal of Engineering Education, 103*(3), 417–449. https://doi.org/10.1002/jee.20048.

Daly, S. R., Yilmaz, S., Christian, J. L., Seifert, C. M., & Gonzalez, R. (2012). Design heuristics in engineering concept generation. *Journal of Engineering Education, 101*(4), 601–629. https://doi.org/10.1002/j.2168-9830.2012.tb01121.x.

DETYA (2000). *Employer satisfaction with graduate skills: Research report.* Australia: Canberra.

Commission, European (2006). Implementing the Community Lisbon Programme: Fostering entrepreneurial mind-sets through education and learning. Retrieved from http://eur-lex. europa.eu/LexUriServ/LexUriServ.do?uri5COM:2006:0033:FIN:EN:PDF.

Ford, J. D., & Riley, L. A. (2003). Integrating communication and engineering education: A look at curricula, courses, and support systems. *Journal of Engineering Education, 92*(4), 325–328. https://doi.org/10.1002/j.2168-9830.2003.tb00776.x.

FYA (2016). *The new basics: Big data reveals the skills young people need for the New Work Order.* Foundations for Young Australians report.

Garg, N. (2019). Misery wants control: The roles of helplessness and choice in the sadness-consumption relationship. *Australian Journal of Management, 44*, 407–424. https://doi.org/10.1177/0312896219830152.

Ghasemaghaei, M., & Calic, G. (2020). Assessing the impact of big data on firm innovation performance: Big data is not always better data. *Journal of Business Research, 108*, 147–162. https://doi.org/10.1016/j.jbusres.2019.09.062.

Gobble, M. (2013). Big data: The next big thing in innovation. *Research and Technology Management, 56*(1), 64–66. https://doi.org/10.5437/08956308X5601005.

Gonzalez-Quevedo, A. A., Mercado-Sherman, L. E., Kruckemeyer, K. E., & Wilson, N. H. M. (2000). The Tren Urbano UPR/MIT Professional Development Program. *Journal of Engineering Education. 89*(2), 127–132. https://doi.org/10.1002/j.2168-9830.2000.tb00506.x.

Graduate Careers Australia (2007). *Snapshot: Graduate Outlook 2007.* Parkville, Australia: A summary of the Graduate Outlook Survey.

Groenewald, T. (2004). Towards a definition for cooperative education. In R. K. Coll, & C. Eames (Eds.). *International handbook for cooperative education: An international perspective of the theory, research and practice of work-integrated learning* (pp. 17–25). Boston, MA: World Association for Cooperative Education.

Hager, P., & Holland, S. (2006). *Graduate attributes, learning and employability.* Dordrecht, Netherlands: Springer.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (2006). *Multivariate data analysis.* New Jersey: Prentice Hall.

Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review, 84*(4), 495–504. https://doi.org/10.17763/haer.84.4.34j1g68140382063.

Hambur, S., Rowe, K., Tu Luc, L., & Australian Council for Educational Research (2002). Graduate skills assessment. Stage one validity study. Canberra, Australia: DEST.

Haenlein, M., & Kaplan, A. (2019). A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California Management Review, 61*(4), 5–14. https://doi.org/10.1177/0008125619864925.

Huq, A., & Gilbert, D. (2017). All the world'sa stage: Transforming entrepreneurship education through design thinking. *Education & Training. 59*(2), 155–170.

Jackson, D. (2013). The contribution of work-integrated learning to undergraduate employability skill outcomes. *Asia-Pacific Journal of Cooperative Education, 14*(2), 99–115. https://www.ijwil.org/files/APJCE_14_2_99_115.pdf.

Jackson, D., & Chapman, E. (2012). Non-technical competencies in undergraduate business degree programs: Australian and UK perspectives. *Studies in Higher Education, 37*(5), 541–567. https://doi.org/10.1080/03075079.2010.527935.

Jackson (2010). An international profile of industry-relevant competencies and skill gaps in modern graduates. *International Journal of Management Education, 8*(3), 29–58.

Jackson, B., Gordon, J. R., & Christholm, J. (1996). A Learning Experience: The Technology Innovation Program. *Journal of Engineering Education. 85*(4), 309–315. https://doi.org/10.1002/j.2168-9830.1996.tb00250.x.

Jakobsen, M., & Jensen, R. (2015). Common method bias in public management studies. *International Public Management Journal, 18*(1), 3–30. https://doi.org/10.1080/10967494.2014.997906.

Jenson, I., Leith, P., Doyle, R., West, J., & Miles, M. P. (2016a). Innovation system

problems: Causal configurations of innovation failure. *Journal of Business Research, 69*(11), 5408–5412.
Jenson, I., Leith, P., Doyle, R., West, J., & Miles, M. P. (2016b). The root cause of innovation system problems: Formative measures and causal configurations. *Journal of Business Research, 69*(11), 5292–5298. https://doi.org/10.1016/j.jbusres.2016.04.146.
Jiusto, S., & Dibiaso, D. (2006). Experiential learning environments: Do they prepare our students to be self-directed, life-long learners? *Journal of Engineering Education. 95*(3), 195–204. https://doi.org/10.1002/j.2168-9830.2006.tb00892.x.
Kaplan, A., & Haenlein, M. (2019). Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Business Horizons, 62*(1), 15–25. https://doi.org/10.1016/j.bushor.2018.08.004.
Kirn, A., & Benson, L. (2018). Engineering Students' Perceptions of Problem Solving and their Future. *Journal of Engineering Education. In-Press.*. https://doi.org/10.1002/jee.20190.
Kinnear, T. C., Taylor, J. R., Johnson, L., & Armstrong, R. (1993). *Australian marketing research.* Roseville: McGraw-Hill.
Kline, R. B. (2005). *Principles and practice of structural equation modeling.* New York, London: The Guilford Press.
Knight, P., & Yorke, M. (2004). *Learning, curriculum and employability in higher education.* London: RoutledgeFalmer.
Lamancusca, J. S., Zayas, J. L., Soyster, A. L., Morell, L., & Jorgensen, J. (2008). The Learning Factory: Industry-Partnered Active Learning. *Journal of Engineering Education. 97*(1), 5–11. https://doi.org/10.1002/j.2168-9830.2008.tb00949.x.
Lazzeretti, L., & Capone, F. (2016). How proximity matters in innovation networks dynamics along the cluster evolution. A study of the high technology applied to cultural goods. *Journal of Business Research, 69*(12), 5855–5865. https://doi.org/10.1016/j.jbusres.2016.04.068.
Male, S. A., et al. (2017). Gender Inclusivity of Engineering Students' Experiences of Workplace Learning at Three. *Australian Universities. Journal of Engineering Education. In-Press.*. https://doi.org/10.1080/03043797.2011.569703.
McNeill, N., Douglas, E. P., Ljungberg, D. T., & Krause, I. (2016). Undergraduate students' beliefs about engineering problem solving. *Journal of Engineering Education. 105*(4), 560–584. https://doi.org/10.1002/jee.20150.
McWilliam, E., & Dawson, S. (2008). Teaching for creativity: Towards sustainable and replicable pedogogical practice. *Higher Education Research & Development, 56*, 633–643. https://doi.org/10.1007/s10734-008-9115-7.
Moenaert, R. K., Caeldries, F., Lievens, A., & Wauters, E. (2000). Communication flows in international product innovation teams. *Journal of Product Innovation Management, 17*(5), 360–377. https://doi.org/10.1016/S0737-6782(00)00048-5.
Möller, K., & Halinen, A. (2017). Managing business and innovation networks—From strategic nets to business fields and ecosystems. *Industrial Marketing Management, 67*, 5–22. https://doi.org/10.1016/j.indmarman.2017.09.018.
Montag-Smit, T., & Maertz, C. P., Jr (2017). Searching outside the box in creative problem solving: The role of creative thinking skills and domain knowledge. *Journal of Business Research, 81*, 1–10. https://doi.org/10.1016/j.jbusres.2017.07.021.
Moon, J. W., & Kim, Y. G. (2001). Extending the TAM for a World-Wide-Web context. *Information & Management, 38*(4), 217–230. https://doi.org/10.1016/S0378-7206(00)00061-6.
National Innovation and Science Agenda (2016) https://www.innovation.gov.au/ Accessed February 14, 2018.
National Committee of Inquiry into Higher Education (1997). *Higher education in the learning society [Dearing report].* London: Her Majesty's Stationery Office.
Australia's Chief Scientist (2015) Boosting High-Impact Entrepreneurship in Australia-— A role for universities, Australian Government, October 2015.
Passow, H. J. (2012). Which ABET competencies do engineering graduates find most important in their work? *Journal of Engineering Education, 101*(1), 95–118. https://doi.org/10.1002/j.2168-9830.2012.tb00043.x.
Phillips, V., & Bond, C. (2004). Undergraduates' experience of critical thinking. *Higher Education Research & Development, 23*, 277–294. https://doi.org/10.1080/0729436042000235409.
Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology, 63*(1), 539–569. https://doi.org/10.1146/annurev-psych-120710-100452.
Quality Assurance Agency for Higher Education (QAA). (2012). Enterprise and entrepreneurship education guidance for UK higher education providers. Draft for consultation, February 2012. Retrieved from http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/EE_Draft_Guidance.pdf, (n.d.) 03.11.2012.
Rampersad, G., & Patel, F. (2014). Creativity as a Desirable Graduate Attribute: Implications for Curriculum Design and Employability. *Asia-Pacific Journal of Cooperative Education, 15*(1), 1–11. https://www.ijwil.org/files/APJCE_15_1_1_11.pdf.
Rampersad, G. C. (2015). Developing university-business cooperation through work-integrated learning. *International Journal of Technology Management, 68*(3–4), 203–227. https://doi.org/10.1504/IJTM.2015.069664.
Rampersad, G. (2014). Perceptions of Creativity in University-Industry Partnerships: A Pedagogical Approach. *International Journal of Innovation and Technology Management, 11*(06), 1450045. https://doi.org/10.1142/S021987701450045X.
Rampersad, G., & Jarvis, J. (2012). Developing Innovation Skills Through Work-integrated Learning. *Global Perspectives on Engineering Management. 2*(4), 165–174.
Redish, E. F., & Smith, K. A. (2008). Looking beyond content: Skill development for engineers. *Journal of Engineering Education, 97*(3), 295–307. https://doi.org/10.1002/j.2168-9830.2008.tb00980.x.
Rychen, D. (2002). Key competencies for the knowledge society: A contribution from the OECD Project Definition and Selection of Competencies (DeSeCo). Education - Lifelong Learning and the Knowledge Economy Conference, Stuttgart, Germany.
Scott, G., & Yates, K. W. (2002). Using successful graduates to improve the quality of undergraduate engineering programmes. *European Journal of Engineering Education, 27*(4), 363–378. https://doi.org/10.1080/03043790210166666.
Shuman, L., Besterfield-Sacre, M., & McGourty, J. (2005). The ABET "Professional Skills" - Can they be taught? Can they be assessed? *Journal of Engineering Education. 94*(1), 41–55. https://doi.org/10.1002/j.2168-9830.2005.tb00828.x.
Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods. *Journal of Business Research, 70*, 263–286. https://doi.org/10.1016/j.jbusres.2016.08.001.
Sousa, M. J., & Rocha, Á. (2019). Skills for disruptive digital business. *Journal of Business Research, 94*, 257–263. https://doi.org/10.1016/j.jbusres.2017.12.051.
Spellings, M. (2006). *A test of leadership: Charting the future of U.S. higher education.* Washington, DC: U.S: Department of Education.
Standish-Koun, T., & Rice, M. P. (2002). Introducing engineering and science students to entrepreneurship: Models and influential factors at six American universities. *Journal of Engineering Education. 91*(1), 33–39. https://doi.org/10.1002/j.2168-9830.2002.tb00670.x.
Sternberg, R. J., & O'Hara, L. A. (1999). *Creativity and intelligence.* In R: Sternberg. Handbook of Creativity. Cambridge University Press. Cambridge U.K.
Taks, M., Tynjala, P., Toding, M., Kukemelk, H., & Venesaar, U. (2014). Engineering Students' Experiences in Studying Entrepreneurship. *Journal of Engineering Education. 103*(4), 573–598. https://doi.org/10.1002/jee.20056.
West, S. G., Finch, J. F., & Curran, P. J. (1995). *Structural equation models with nonnormal variables, in structural equation modeling: Concepts, issues and applications* (pp. 256–293). Newbury Park, CA: Sage.
Wilkins, K. G., Bernstein, B. L., & Bekki, J. M. (2015). Measuring communication skills: The STEM interpersonal communication skills assessment battery. *Journal of Engineering Education, 104*(4), 433–453. https://doi.org/10.1002/jee.20100.
Woods, D. R., Hrymak, A. N., Marshall, R. R., Wood, P. E., Crowe, C. M., Hoffman, T. W., ... Bouchard, C. G. (1997). Developing problem solving skills: The McMaster problem solving program. *Journal of Engineering Education, 86*(2), 75–91. https://doi.org/10.1002/j.2168-9830.1997.tb00270.x.
Xie, X., & Wang, H. (2020). How can open innovation ecosystem modes push product innovation forward? An fsQCA analysis. *Journal of Business Research, 108*, 29–41. https://doi.org/10.1016/j.jbusres.2019.10.011.
Yang, M., & Han, C. (2019). Stimulating innovation: Managing peer interaction for idea generation on digital innovation platforms. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2019.08.005.

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