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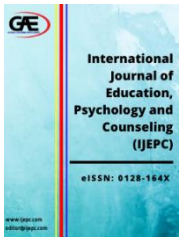

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EXPLORING THE RELATIONSHIP BETWEEN ENGINEERING STUDENTS' SKILLS AND READINESS TOWARD INDUSTRY REVOLUTION 4.0

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Abstract:

To move into the industrial revolution (IR) 4.0, the manufacturing sector faced some challenges, one of them is the shortage of skilled workforce. Previous studies also determined a lack of awareness and knowledge of IR 4.0 and Malaysian students still lack the necessary skills to work in the IR 4.0 era. Thus, the objectives of this study are to conceptualize the students' skills towards adapting to IR 4.0. The study will discover IR 4.0 required skills, and the significant factors influencing students' readiness, and the findings will also contribute to some solutions to improve students' skills. This study is significant to the students, university, industry as well as policymakers. Students will increase their understanding of the required skills in the IR 4.0 era. University will gain input to provide quality education to equip the students with necessary skills. Besides, the industry can gain benefits from education development. Therefore, the issue of shortage of skilled workforces can be reduced. This study also will acknowledge the policy makers towards preparing future workforces and meeting the government objectives of implementing IR 4.0, particularly in the manufacturing sector in Malaysia.

Keywords:

Industry Revolution, Higher Education, Soft Skills, Technical Skills

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Introduction

One of the challenges to pursue IR 4.0 is the skilled workforce (Yong, Nor Aziati, & Lee, 2020; Tay, Lee, Chan, Alipal, & Abdul Hamid, 2019; Stock & Seliger, 2016; Muller, Kiel, & Voigt, 2018). As per record, there are more than 2 million employees in the manufacturing sector, which consists of 75% semi-skilled workers, while only 18% of workers are highly skilled. As supported by MITI (2018) in Malaysia, there are still issues related to the shortage of skills, talents, and knowledge required in IR 4.0 specifically in the area of robotics, the internet of things, and artificial intelligence. Thus to meet the objectives, it is important to enhance the effort to produce a skilled and diverse workforce by upgrading the existing employees and developing future employees in the manufacturing sector. Students should be prepared with the necessary skills to work in the IR 4.0 era. The skill issue is a serious issue since existing training programs in Malaysia are insufficient, and still lack experts in universities, industry, and training institutes across most IR 4.0 technologies (Yong et al., 2020; MITI, 2018).

However, in this industrial era, employers need to ensure that their employees are equipped with not only technical skills such as digital, information technology, and automation but also non-technical skills (Ismail, Wan Hassan, Ahmad, Affan, & Harun,2020). Equivalent to previous industrial revolutions, in IR 4.0, skills development is also an important issue to be solved by the industry, education institutions, and government. It requires students to master a new skill and they should be well prepared with the necessary skills and knowledge to meet the IR 4.0 expectation (Mohd Kamaruzaman, Hamid, Mutalib, & Rasul, 2019). As indicated by Maisiri, Darwish, & Van Dyk (2019) an engineer needs to have a balance between technical and non-technical skills to remain relevant in this industrial era. Meanwhile, as mentioned by Azmi, Noordin, Kamin, Md Nasir, & Sihairom (2018) engineering students still lack nontechnical skills. This is a challenge for universities to prepare or improve the education programs to enhance the nontechnical skills among engineering students. As stated by The National Graduate Employability 2012-2017, Malaysian graduates still lack technical skills and knowledge.

Besides, the results also determined that poor character, attitude or personality (37.4%), mismatch of skills (30.2%), and solving problems (25.9%) as some of the problems faced by employers to hire fresh graduates. Previous studies have discussed the important skills among students (Azmi et al., 2018; Zaharim et al., 2010; Salleh, 2019; Rahman, Mokhtar, Mohd Yasin, & Mohd Hamzah, 2011; Md Saad, & Majid, 2014). However, as mentioned by Mohd Kamaruzaman et al. (2019) the skills identified by previous studies were no longer appropriate for the current industry requirements or expectations. Thus, there is a need to further investigate the issue to match the current challenges of IR 4.0. Table 1 is the summary of previous studies on students' skills in IR 4.0 conducted in the Malaysian context. Based on reviews, there are still some gaps to be filled such as the findings based on academician and industry perspectives on students' skills are limited. Most of the past studies are only based on the perspective of students in a specific faculty or university. In addition, previous studies discussed were based on descriptive analysis, thus conducting this study helps to reduce the gaps and contribute to developing the complete picture of students' skills and readiness toward IR 4.0 in Malaysia. Due to these issues, this study aims to propose a framework for students' readiness for IR 4.0.

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Table 1: Summary of Previous Studies On Students' Skills During IR 4.0 In Malaysia

Author	Year	Scope	Research method
Rahmat, Adnan, & Mohtar	2019	➢ Undergraduate students ➢ Identify students' skills during IR 4.0	➢ Quantitative: Survey questionnaire ➢ Analysis: Descriptive analysis
Ahmad, Segaran, Ng, Md Sapry, & Omar	2019	➢ Undergraduate at Faculty Technology Management and Business ➢ Identify the factor toward students' readiness on IR 4.0	➢ Quantitative: Survey questionnaire ➢ Analysis: Descriptive analysis
Ismail et al.	2020	➢ Student at a Malaysia Technical University ➢ Identify student readiness on IR 4.0	➢ Quantitative: Survey questionnaire ➢ Analysis: Descriptive analysis
Yong et al.	2020	➢ Issue or challenges in IR 4.0	➢ Systematic literature reviews
Ajmain Jima'ain, Abu Hassan, Abdul Razak & Junaidi	2020	➢ 35 Students from 4 universities ➢ Challenges and skills required during IR 4.0	➢ Qualitative: Interview ➢ Analysis: Thematic method
Mohd Kamaruzaman et al.	2019	➢ Skill required during IR 4.0	➢ Systematic literature reviews
Tay et al.	2019	➢ Challenges in IR 4.0	➢ Literature reviews

Literature Review

To ensure the students are ready to meet the industry requirements during IR 4.0, the university should equip them with the necessary skills. To be a worker in this industrial era, students should have both skills which are technical and non-technical skills.

Technical and Non-Technical Skills

As mentioned by Jelonek, Nitkiewicz, & Koomsap (2020) technical skills are very important for engineers. Besides, nowadays, employers also consider non-technical skills such as communication and teamwork skills. Engineers need to have good nontechnical skills to deal with customers or suppliers. In addition, engineers also need to have good communication skills to share their knowledge and experience, teamwork skills, and creative thinking skills to solve complex problems in the company and to brainstorm among the engineering team. As supported by Azmi et al. (2018), an employee with critical thinking and problem-solving skills can generate some creative or new ideas which benefit company development. This is in line with Suarez Fernandez-Miranda, Marcos, Peralta, & Aguayo (2017) whereby indicated that in the manufacturing sector, creative thinking and decision-making skills are crucial, as well as

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technical skills. The qualified or skilled workforces in the manufacturing sector depend on the quality of the education system and facility availability.

A study conducted by Kamaruzaman et al. (2019) identified some skills required by the graduates in IR 4.0 such as problem-solving, critical thinking, creativity, people management, emotional intelligence, decision making, and negotiation. A study supported by Rahmat et al. (2019) highlighted that emotional intelligence is the major skill possessed by undergraduate students to meet the IR 4.0 requirements. This skill received the highest total mean followed by other important skills such as decision making, people management, creative thinking, and negotiation meanwhile problem solving, critical thinking, and service orientation are some of the skills which received the lowest score by the students. In addition, a study conducted in Malaysia by Ahmad et al. (2019) also divided skills into technical and non-technical skills. Technical skills refer to digital skills meanwhile non-technical skills consist of communication, leadership, and problem-solving skills. The result showed that communication is one of the important non-technical skills that should be considered during this revolution era. Ajmain Jima'ain et al. (2020) also supported communication as one of the important required skills in the IR 4.0 era. In addition, the informants in the study also determined some other important skills such as time management skills, information, and communication technology skills, thinking and teamwork skills.

Maisiri et al. (2019) summarized the required skills during IR 4.0 into two which are technical and non-technical skills. Technical skills consist of technology skills, programming skills, and digital skills. Meanwhile, non-technical skills are categorized into thinking, social and personal skills. Based on the study, in IR 4.0, engineers need to have skills in coding, software development, ability to work with the internet of things, 3D printing, autonomous robot, digital, cyber security, cloud computing skills, data analytics, artificial intelligence as well as non-technical skills such as lifelong learning, communication, leadership, and some others necessary skills. In this industry 4.0 era, lifelong learning is crucial for engineers to continuously improve or develop their skills to meet the current rapid advance technology change. A study by Hecklau, Galeitzkea, Flachsa, & Kohlb (2016) also determined these skills as the required skill in IR 4.0, the study divided the skills into four main categories, technical, methodological, social, and personal competencies. Based on the reviews, this recent study divides the students' skills into two, which are technical and non-technical skills. Technical skills consist of technology, programming, and digital skills. Meanwhile, non-technical skills consist of thinking, social and personal skills as suggested by Maisiri et al. (2019). The details of engineering students' skills required during IR 4.0 are shown in table 2.

Table 2: Summary of Skills Required During IR 4.0

Variable		Description	References
Technical skills	Technology skills	Fault and error recovery skill	Maisiri et al. (2019)
		Ability to work with IoT, 3D printing, autonomous robots, and other advanced technologies	Maisiri et al. (2019)
		Interaction with modern interfaces	Maisiri et al. (2019)

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	Programming skills	Coding	Maisiri et al. (2019); Hecklau et al. (2016)
		Simulation skill	Maisiri et al. (2019)
		Computer and software programming skills	Maisiri et al. (2019)
		Software development	Maisiri et al. (2019)
	Digital skills	Data analytics	Maisiri et al. (2019)
		Cyber security	Maisiri et al. (2019): Hecklau et al. (2016)
		Cloud computing skill	Maisiri et al. (2019)
		IT knowledge and abilities	Ahmad et al. 2019; Maisiri et al. (2019); Ajmain Jima'ain et al. (2020)
		Artificial intelligence skill	Maisiri et al. (2019)
		Digital content skill	Ahmad et al. 2019; Maisiri et al. (2019)
Non-Technical skills	Thinking skills	Creative thinking	Rahmat et al. 2019; Maisiri et al. (2019); Jelonek et al. (2020); Hecklau et al. (2016)
		Complex problem solving	Ahmad et al. 2019; Rahmat et al. 2019; Maisiri et al. (2019); Jelonek et al. (2020); Hecklau et al. (2016); Abd Rahman et al. 2019
		Critical and logical thinking	Rahmat et al. 2019; Maisiri et al. (2019); Ajmain Jima'ain et al. (2020)
		Decision making	Hecklau et a. (2016)
	Social skills	Teamwork	Rahmat et al. 2019; Maisiri et al. (2019); Hecklau et al. (2016); Ajmain Jima'ain et al. (2020)
		Communication skill	Maisiri et al. (2019); Jelonek et al. (2020); Ahmad et al. (2019); Ajmain Jima'ain et al. (2020)
	Personal skills	Leadership	Ahmad et al. 2019; Rahmat et al. 2019; Maisiri et al. (2019); Hecklau et al. (2016)
		Lifelong learning	Maisiri et al. (2019)

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	Emotional intelligence	Rahmat et al. 2019; Maisiri et al. (2019)
	Negotiation skill	Rahmat et al. 2019; Maisiri et al. (2019); Jelonek et al. (2020)

Students' Readiness Toward Industry Revolution 4.0

The 'future of job' reports by The World Economic Forum (WEF) has listed ten (10) critical skills for the future of work for the year 2020 and beyond. Among the critical skill sets are critical thinking, people management, creativity, complex problem solving, emotional intelligence, coordinating with others, service orientation, negotiation, decision making, and cognitive flexibility. These skill sets are known as soft skills, however, in the post-industry 4.0 era, these skills are no longer seen as soft or substandard to technical skills. Yet, these skills are perceived as core skills that are required not just for the sake of survival but also important to succeed in the future workplace (Rahmat et al., 2019). These skills are perceived to be critical core skills to secure future jobs and vital to contribute to the industry 4.0 economy and society in a productive manner. Furthermore, the younger generation or future graduates find it challenging to acquire these skills without continuous and directed effort. Moreover, failure to acquire these skills will lower the career readiness level of the younger generation of future workers (Rahmat et al., 2019). Nowadays, companies and manufacturers are struggling to find workers because of the lack of students' preparations across several different features to join the workforce (Ahmad et al., 2019). In addition, this concern is reasonable because the industry needs skilled workers with strong academic backgrounds (Flory, 2017). Nevertheless, some of the graduates are uninformed about the current demand. Students cannot relate to or do not see the connection between academic lessons conducted in the classroom with the real world of work (Ahmad et al., 2019).

Besides, most students are concerned about getting a good grade and often neglected the right skill sets to be successful in the workforce. A study conducted by Inti International University and Colleges to uncover if students were ready to be part of a digitally evolving workforce found that the students, graduates, and parents were not well informed on IR 4.0. In addition, the findings also found that students felt that they were unprepared to join the IR 4.0 workforce. The study also mentioned that tertiary education like a university "may not be doing enough to prepare students for the workplace". The study involved 560 respondents including graduates, students, and parents. Furthermore, according to Tan Lin Nah, the acting chief executive officer of Inti International University and Colleges, even though there were several IR 4.0 initiatives introduced by the government and industry, most students and graduates responded that they were incompetent and unable to eloquent what IR 4.0 demands (New Straits Times, 2019). Similarly, most parents surveyed were unable to discuss IR 4.0 and the relevancy to the transformation of the organization. Students lack exposure on IR4.0 and relied too much on academic programs to make them job-ready. Hence, universities should assess and evaluate how well their programs deliver real-world insights to graduates towards joining the workplace. Tan further added that "While the emphasis on STEM (Science, Technology, Engineering, and Mathematics) education is on the rise, students are unable to articulate or envision how their choice of education and careers today may be impacted by digital change."

Ways to Improve Student Technical and Non-Technical Skills

Education institutions, government, and industry should be working together to ensure students are well-prepared to work in IR 4.0 era, particularly in the manufacturing sector (Ajmain

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Jima'ain et al., 2020). To produce graduates with the necessary skills, universities and industry should have effective collaboration between both institutions (Maisiri et al., 2019; Ajmain Jima'ain et al., 2020). Universities can invite the industry to share their experience and knowledge (Ajmain Jima'ain et al., 2020). Thus, it will enhance students' knowledge and understanding of the required skills in IR 4.0. Besides, the inputs from the industry are needed to ensure the university education program is in line with the current IR 4.0 requirements. As discussed by Nguyen & Huynh (2020) they proposed a training model to equip the students with non-technical skills such as problem-solving, critical thinking, and creativity skills. MITI (2018), indicated introducing a certificate program related to develop skills among workforces in IR 4.0 era. Suarez Fernandez-Miranda et al. (2017) also believed that through established collaboration between government and industry, develop training and university programs can lead to enhance workforce skills.

As mentioned by MITI (2018) in the National Policy on Industry 4.0, there are two strategies to solve the skill workforces issue to fulfill the IR 4.0 requirement in Malaysia. The first strategy is to up-skill and re-skill the existing workforces in manufacturing sectors and the second strategy is to ensure the availability of future workforces with the necessary skill for IR 4.0. Several action plans are proposed to meet the strategies such as boosting financial support to implement TVET and STEM education programs. Besides, by including theory and practical application of IR 4.0 in the tertiary education curriculum, it also encourages involvement in industry placement. In addition, to educate the young generation, the capacity and capability of trainers and lecturers should be enhanced. Thus, it helps to prepare the students with updated knowledge and skills to deal with advanced technology development in IR 4.0. Based on the policy, there are some efforts to promote the manufacturing sectors among the public to attract graduates and high-skilled workers to join this economic sector.

Research Framework

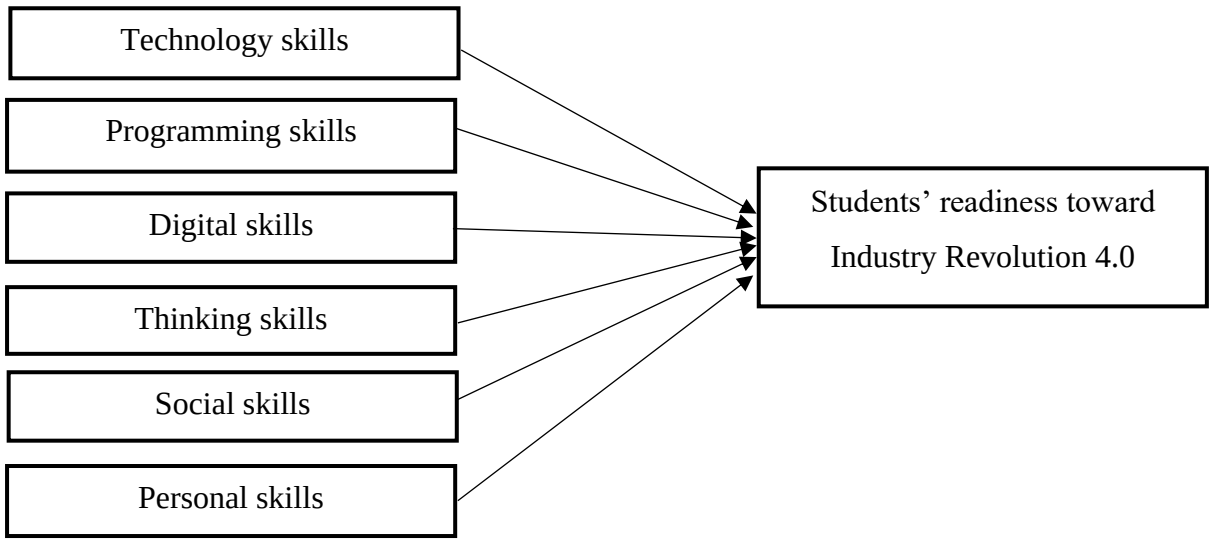

Figure 1: Framework on The Relationship Between Students' Skills and The Readiness Toward IR 4.0

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Figure 1 shows the theoretical framework, which includes 6 independent variables (technical and soft skills) and student's readiness on IR 4.0 as a dependent variable. Based on literature reviews and theoretical framework, below are the proposed hypotheses:

H1: Technology skills have a significant relationship with students' readiness for IR 4.0
H2: Programming skills have a significant relationship with students' readiness for IR 4.0
H3: Digital skills have a significant relationship with students' readiness for IR 4.0
H4: Thinking skills have a significant relationship with students' readiness for IR 4.0
H5: Social skills have a significant relationship with students' readiness for IR 4.0
H6: Personal skills have a significant relationship with students' readiness for IR 4.0

Conclusion

Skilled workforces or talents are important during IR 4.0, it contributes to the economy, environment, and national development. Besides, a sufficient skilled workforce contributes to the effective and efficient development of advanced technology which leads to benefit the society. The Malaysian manufacturing sector can compete with the developed countries if one of the challenges which is talent management is reduced by raising educational standards in accordance with the IR 4.0 requirements. This study acknowledges and guides the government and policymakers on the recent engineering students' skills and readiness toward the IR 4.0. Besides, the reviews will also generate more ideas based on the perspectives of academicians, students, and employers especially on the proposed strategies in the national industry 4.0 policy-framework. However, this study is limited to conceptual reviews, thus, to reduce this limitation and the gaps on the students' readiness toward accepting industry 4.0 in Malaysia, future studies are encouraged to adapt this framework and to provide empirical evidence based on the Malaysian students' perspectives. Therefore, it is hoped that the government and policymakers would develop and formulate the best plan for fulfilling the IR 4.0 requirements.

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