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An Investigation of Present and Future Work Skills in Industry 4.0: Systematic Literature Review

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ABSTRACT

The wave of Industry 4.0 which built on technology advancements has brought significant changes in the requirement of skills and qualifications. Industry 4.0 affects not only all industries, but the education sector as well. As preparation to respond towards the wave of Industry 4.0, Malaysian government emphasized on the need to prepare youth who are ready for future technology that change radically. In doing so, the youth in Malaysia as representative of present and future workforce which required to master some blended of skills. This paper will perform a systematic literature review in order to investigate present skill and future skill that meet the requirement of Industry 4.0. The impact of Industry 4.0 to education sector and manufacturing industry will be discussed. This paper also investigates to seek to bridge the gap between present skills and future skills of Industry 4.0 in Malaysia.

Keywords:
Manufacturing; skills; industry 4.0

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1. Introduction

The name of fourth industrial revolution which also known as Industry 4.0 is frequently mentioned all around the world. Considering that Industry 4.0 is a new transformation from the past industrial revolution [1]. Due to drastic transformation in the Industry 4.0, it became challenges for the world of business [2]. However, the impact of Industry 4.0 not only within the industries and education but as well as future workforce. Due to the technological advancement, this required the workforce that highly skilled in order to use the equipment of automated machine tools and robots. Industry demanded the potential workforce that capable for the future industries. In order to get potential workforce, Higher Education Institution (HEI) is one of the places to produce skilled workforce [3] for the industries. This is due to one of the ways to improve the quality workforce is with the quality of the education itself [4]. Hence, it is suggested for HEI to supply future workforce who are ready to adapt with the technological change with the completed employability skills.

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'Employability' term has been used oftenly as a dimension by employers on marketability among the graduates [5]. In Malaysia, employability skill usually referred as someone's ability to master the skills and attributes that meet the needs of the job demand by getting a job in the field of study [6]. Rasul, Abdul Rauf, Mansor and Puvanasvaran [7] had declared that employability skills not just improving skills, techniques and experiences to get a job, but it also involves on how the individual are performing the assigned tasks while working. Padil [8] concluded that employability skills are additional skills required by graduates to improve personal quality in preparing themselves for the present and future world of work. In other words, the effect of latest technological change will require a transformation in the demanded of the workforce skill [9].

Nowadays, the technological change which related to Industry 4.0 will include transformation in many aspect like economy from agriculture to manufacturing, from modern technology to advanced technology and from traditional mentality to progressive mentality and so on [10]. According to Silva and Lima [11], Industry 4.0 also affect employment and corresponded with the skills demanded to adopt with the new processes of the productions in industry. After the announcement made by federal government of German, Industry 4.0 become the focus topic among industries, research centres and higher learning institutions. Industry 4.0 is one of German key initiatives on high technology strategy in 2011. Numerous academic publications, practitioners, practical articles, and conferences have discussed on this hot topic [12]. Industry 4.0 will change the nature of work due to the replacement of fully automation machine tools and robots, as skills demanded for the job market in the future especially in manufacturing industry. This is due to manufacturing industries are more likely to use high technology in producing its output [13]. Moreover, the Industry 4.0 has required teaching and learning process to align with the technology advancement, which result to the integration of technology such as Artificial Intelligence (AI) in that process [14].

Presently, the development of Industry 4.0 has substantial influence on the manufacturing industry which the equipment will be characterized by the machine and tools that are highly automated [15]. The manufacturing industry has played a big role in the effort of developing countries to grow and prosper. This has been experienced by Malaysian economic since 1960s [16]. All industry over the world especially manufacturing industry has experience increased competition, in order to improve productivity, in ensuring quality and increasing delivery reliability [17].

Nowadays, the issue of unemployment among graduates giving attention from every stakeholders [16]. This due to number of graduates leave their institution without necessary skills required by the industry. Higher education institution in Malaysia has produced a huge number of graduates for every year [18]. This based on the statistic of higher education published by Ministry of Education in 2018, which showed that admission to public universities in 2018 are 112 649 compared to 2017 which record the total admission of students are 108 715. Thus, this issue will lead to the increasing number of unemployment among graduates [18]. To complicate, pandemic Covid-19 brings huge impacts to all sectors, including education sector as teaching and learning process change towards online learning, which further bring another challenges to teachers and students [19].

Today, there is a huge collaboration between higher education institution and industry [20]. Some scholars stated that employers demand higher education institution to produce graduates with appropriate skills [21]. However, employers disputed that higher education institution were having different perceptions in work behavior and mentality [22]. This due to higher education institution were not prepared to accept and collaborate with the outcome-oriented culture in industry [22]. This can be understood by the government that to ensure that the gap between higher education institution and industry is minimized, it is important to provide soft skill and hard skill training for the graduates [18].

Although many studies have focused on employability skills, the foresight study on specific framework still unclear for future workforce skills that affected by Industry 4.0, especially in Malaysia. Therefore, it is a requirements to study on the future workforce specific skills in different perspective such as from employers, education and policy makers itself. This to ensure to facilitate preparation of future workforce with high skilled. Most of the studies in future workforce skills especially in foresight study has attempt to predict skills requirement as a whole.

This paper seek to investigate present and future work skills that meet the requirement respect to the Industry 4.0 through the Systematic Literature Review (SLR) approach that been performed. The impact of Industry 4.0 to education sector and manufacturing industry will be discussed. This paper also investigate to seek to bridge the gap between present skills and future skills of Industry 4.0 in Malaysia.

2. Literature Review

2.1 Overview of Industry 4.0

In the past few years, technological change and development has affected the industries [23]. The main idea of this Fourth Industrial Revolution was firstly announced in 2011 by Kagermann [15]. The phenomenon of this Fourth Industrial Revolution (also known as Industry 4.0) was first proposed during Hannover Fair in 2011 at German. It is a proposal of a new concept for the development for German economic policy which related to high-tech strategies [20,24].

There are four stages in the continuing development of the industrial revolution [25,26]. The first industrial revolution or known as Industry 1.0 began in year 1784. It has emerged in the late of 18th century by the formation of mechanization with the introduction of mechanical production processes driven by water and steam power. The second industrial revolution which referred as Industry 2.0 then starts in early 20th century by the establishment of electrical power on mass production and conveyor belts, while the entrance of computer and electronics to further enhance automation of manufacturing are the signal of the third industrial revolution (Industry 3.0) at the beginning of 1970s. At present, the latest industrial revolution is Industry 4.0 based on the digitalization of the previous revolution on the use of cyber physical systems.

Technological change demand a shift in the required skills and qualifications [27]. In order to success in highly innovate industries, skill and qualification of workforce are essential due to future manufacturing that use new technologies and smart media [23]. This has been supported by Cicek *et al*., [9] where the Industry 4.0 will demand a transformation in the skills needed by the workforce.

2.2 Theory of Skills

Skill can be described as the ability to achieve something successfully which involve special knowledge, ability or competence. In other meanings, it is also can be represent as an art, which the ability or technique earned through training or experience which include the use of body parts [21]. Graduates are required not to have only academic knowledge but also have soft skills to enhance their competence [28]. Generally, by provided graduates with the skill required for employment will success the economic and more general to economic success of the country [29]. Thus, graduates who possesses soft skills and hard skill will be hired by the employers [21] whereby skills are a valuable asset for graduates to get job in the future [28].

The hard skills and soft skills are refer to category of the skills [30]. Various terminologies have been used by other researchers in defining soft skills [18,31]. Some scholars used generic skills [32], transferable skills [33, 34] teachable skills [35], key skills [36] as well as employability skills [29,37].

The Ministry of Higher Education (MOHE) has listed seven sub-skills related to the soft skills. This skills is the respect to the Malaysian context. These seven skills are communication skill, teamwork skill, critical thinking and problem solving skill, moral and professional ethics, lifelong learning and information management skills, entrepreneurial skills, as well as leadership skills [38].

2.3 Impact of Industry 4.0 on Education Sector

It is crucial to identify firstly the present of learning requirements for training of new generations on the topics related to advance manufacturing. Then, it is required to understand the most appropriate approach to meet those needs. Furthermore, educational solutions need to be develop by engaging student directly in the collaborative design process to ensure validation and enrichment of the content provided to be improved. Due to the wave of Industry 4.0, several effort on the education and training of the stakeholders has been done in order to maintain the rapid changes of manufacturing industry. It is also can reduce the skills gap facing by the manufacturing industry. Among the various ways that can be taken, it is crucial to the higher education institution to identify the requirement of learning for the advanced manufacturing training. This is the most effective educational approaches that will meet those needs and ultimately suggesting concrete solutions [39].

2.4 Impact of Industry 4.0 on Manufacturing Sector

Currently, manufacturing industry are facing substantial challenges related to disruptive concepts such as the Internet of Things (IoT), Cyber Physical System (CPS) or Cloud-based manufacturing. This concepts also referred to Industry 4.0. Manufacturing industries around the world are facing great challenges due to latest environmental, societal, economic and technological developments. Subsequently, increasing complexity at all levels of the firm creates uncertainty about their own organizational and the capabilities in using technology plus with the sufficient strategies to develop them. To overcome the uncertainty and growing dissatisfaction related to the Industry 4.0 of the manufacturing industry, new methods and tools are needed in order to equip the guidance and support for streamlining business strategies and operations [40]. With the rise of the technological development or new digital industry known as Industry 4.0, it is began to reshape the future of manufacturing industry faster than ever. The expected growth and the rapid technological advancement in manufacturing industry will create need for a newly skilled, competent and motivated workforce.

3. Methodology

Laar *et al*., [41] in their study presented a systematic literature review of skills in the era of digitization is agreeable. This method is selected due to it helps to synthesize academic literature accurately and reliably.

3.1 Inclusion and Exclusion Criteria

Based on Liao *et al*., [42] and Liao *et al*., [43], to maintain the objective in the assessment of the collected research paper in Scopus database, inclusion and exclusion criteria need to be formulated. Table 1 shows an overview of the criteria used for inclusion and exclusion research papers.

Table 1

Inclusion and Exclusion Criteria [42,43]

Exclusion/Inclusion	Criteria	Description
Exclusion	Duplication (DP)	The paper with the same criteria appears repeatedly
	Language Compatibility (LC)	The full context of the research papers in not in English exclude title, abstract and any key terms
	No Full-text (NF)	The research paper is not accessible for the full text
	Non-related (NR)	NR1: The research paper is non-reviewed academic article NR2: The research paper not related skill in Industry 4.0
	Casually Applies (CA)	CA1: The research paper used the terms 'Industry 4.0' and 'skills' loosely include with the synonyms terms CA2: The research paper address to Industry 4.0 that not focused on present skill and future skill CA3: The research paper address present skills and future skills, but does not include Industry 4.0
Inclusion	Partially Related (PR)	PR: The Industry 4.0 and skills in general been focused in research paper, but not in manufacturing industry specifically
	Closely Related (CR)	CR1: The research paper explicitly discussed present skill in manufacturing contained the Industry 4.0 CR2: The research paper concentrated on future skill in manufacturing industry that related to Industry 4.0

3.2 Systematic Literature Review Method

The approach of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) has been conducted in this study [44]. This study was conducted under the guidelines adopted from Kitchenham [45]. Search strategy has been presented in Section 3.2.1 and study selection in Section 3.2.2 has been outlined. Data collection has been explained in Section 3.2.3, while Section 3.2.4 describe the data analysis for this research.

3.2.1 Search Strategy

The searching action was conducting using the Scopus databases. The search terms has been determine by identifying the key terms that can be applied from the research questions to the issues related to the focus of study. The key terms taken for inclusion in the searching of the research paper are 'Industry 4.0' and 'skills' respectively. To accommodate difference terms use respect to the spellings as well as synonyms terms, alternative words were identified, as shown in Table 2.

Table 2
Search term alternative spellings and synonyms

Search Term	Alternative Search Words
Industry 4.0	Industry 4.0, Fourth Industrial Revolution, 4th Industrial Revolution, IR4.0
Skill	Competencies, Abilities

Laar *et al*., [41] emphasized that using multiple keywords in order to ensure broad research coverage. Each database has its own indexing, therefore, individual proximity operators are used. As results, the following Boolean search action were performed over a period from January 2015 to February 2020:

• ("Industry 4.0" OR "Fourth Industrial Revolution" OR "4th Industrial Revolution" OR "IR4.0") AND ("Skill*" OR "Competenc*" OR "Abilit*").

3.2.2 Study Selection

The exclusion and inclusion criteria has been applied in this study through the selection of the research paper. Figure 1 presents the SLR phase by using the PRISMA approach.

The first phase in identification stage is identifying papers from Scopus database. The first step is by removing the research paper due to duplicate papers (DP). In the screening stage, the initial screening process is by excluding all research papers that the full context were not in English (LC). However it is exclude the title, abstract, and any keywords. Furthermore, the non-access research papers or in other words is no accessible (NF) will be identified.

After the first screening process, in order to the research papers to be chosen, the eligibility that qualified for inclusion were further examined. The next steps of the screening stage is by eliminating non-reviewed academic articles of the research papers (NR1), and those that were not related to skill required in Industry 4.0 (NR2) including present skills and future skills. On the next stage, the research papers will be eliminated which loosely used the terms of Industry 4.0 and skills (CA1), addressed to Industry 4.0 excluded the present and future skills (CA2), and addressed present and future skills not in the context of Industry 4.0 (CA3).

After the stage of identify the research paper to be removed, the exceed papers of the exclusion criteria are considered eligible. The research paper were examined and reviewed in detail. The eligible papers were classified according to three criteria of the inclusions: papers that focused generally on the skills and Industry 4.0, but not specifically in the manufacturing industry (PR), papers that discuss present skills in manufacturing industry clearly related to Industry 4.0 (CR1), and papers that focus on future skills in manufacturing industry related to Industry 4.0 (CR2).

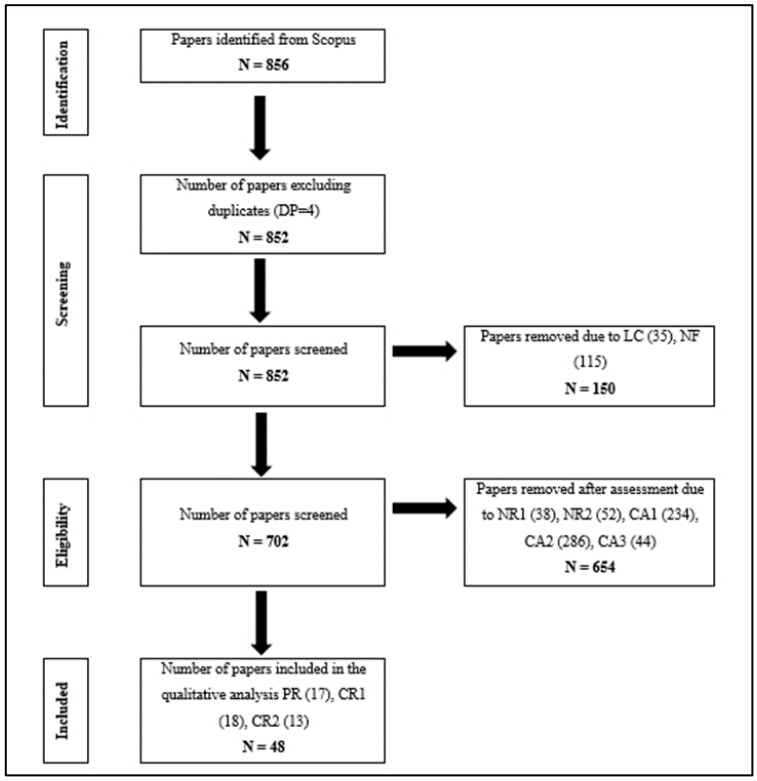

Fig.1 Systematic Literature Review phase using PRISMA approach

3.2.3 Data collection

The data has been taken from the research papers that cover the present and future skill in manufacturing industry in context of Industry 4.0.

3.2.4 Data collection

By apply descriptive codes, the data for this study had been collected were analyzed qualitatively. This was done based on the objective of this research whereby to identifying present skills and future skills in manufacturing industry to the respect of Industry 4.0.

4. Systematic Literature Review Results

4.1 Industry 4.0 Skills Requirement SLR Results

All the related skills in Industry 4.0 were listed, thus providing a wide range of skills. Every category of the skills are divided into subcategories, which then show the skills needed with relevant references (refer to Table 3 and Table 4).

5. Discussion

5.1 Discussion of SLR

The findings obtained from SLR data indicate that soft skills, also called as non-technical skills are increasingly needed in the era of Industry 4.0. Based on the SLR, both present and future skills still emphasized on communication skill, as this skill result with the highest frequency. This is consistent with a recent study by Zaini and Shari [80] as they found that communication skills able to be developed via industrial training. Therefore, it is important to stabilize soft skills and hard skills for the future workforce to be more competent and relevant. Most of skills are not easily automated and this will remain the significant in Industry 4.0.

Due to radical changes in technological advancement that relatively required new skills, abilities of lifelong learning are important in the future workforce, which must continuously improve their skills in respond to the needed for new skills. The level of complexity required in the future workforce has been increases based on technological advancement of Industry 4.0 and automated systems respectively. University students is expected to provide service to the country in becoming an industrialized nation in the future as they are play an important role as a potential source of the future workforce. In addition, student will be a leaders in the future who will shape the direction and develop economic and social of the country. Therefore, in order to prepare them with the skills, university students should equip themselves to increase their employability with both soft and hard skills.

Hard skills also known as technical skills will significantly essential for the future workforce. The relevant skills in Industry 4.0 are technological skills, programming skills, and digital skills. Digital skills that are shown including data analytics and cyber security skills. The use of learning factories is identified as having the ability to stabilize the needed of the future workforce skills.

Nowadays, higher education institution are focusing on prioritizing marketization in the education. Thus, the greater collaboration between higher education institution and industries are very important. This collaboration delivered different advantages between both stakeholders [81]. In order for industry players to look for work-ready among graduates, they should collaborate with higher education institution to ensure that industry are providing the graduates chances to involve

in their organization and having structured learning opportunities (Law, 2018). Besides, teaching and learning process nowadays required some changes in order to suit with the current Industry 4.0. For instance, an application of Internet of Things or IoT in design thinking through IoT programming [82] proof that future workforce demanded them to master with programming and digital skills.

The SLR revealed that, despite the many research papers discusses about Industry 4.0, there was scarce study that focus on the skills needed in the manufacturing industry. Mourtzis [62] argues that technical and methodological efficiency care crucial to the technical workforce. In his study, he has categorized efficiency for Industry 4.0 and lists their importance of the production company with different roles. It emphasizes that non-technical competencies are also clearly important to technical workforce, production engineers and executives [62].

5.2 5.2 Impact on technical and academic institution

Every higher education institution play a big role in produce the graduates with appropriate skill in terms of communication, knowledge and commitment in all areas. The approach in education should be 'hands-on' to ensure that technical skills are relevant to current development. Thus, in order to increase employee productivity in the future, the curriculum should be in proper system. Various effort had been taken by higher education institution to strengthening the curriculum of study to fulfil industry requirements.

6. Conclusion

The findings of SLR have achieved the first and second of the research questions, which ask what type of present and future skills required by manufacturing industry in Industry 4.0. This study shows that soft skills are just important as hard skills in the manufacturing industry in the era of Industry 4.0.

The latest technological advancements in the manufacturing industry with the impact of the Industry 4.0 has required a change in the skills needed by the future workforce. This is an important issue for identifying present and future skills with the integration of new technologies in the manufacturing industry from an industry and education perspective. At this insight, this paper focuses on the analysis and identification of the future skills needed in the manufacturing industry to bridge the gap between the education and industry perceptions.

Considerable efforts is needed to enhance the manufacturing skills for the future workforce and prepared them for the new challenges of the new world of industrialization due to the rapid changes of manufacturing industry towards the vision of the Industry 4.0, However, there are still Malaysian and global shortages of skilled workers that able to foster the advancement of manufacturing sector.

The SLR exposed a gap in the literature review on the specialized skills needed for future manufacturing industry workforce. There is also inadequacy in the literature that discussed on the specific skills in Industry 4.0 in Malaysia. In this regard, it will focus on developing a model that detail the conceptual skills requirements of the future work for different industry. Detailed research on a present and future skills aim at bridging the gap between Industry 4.0 in Malaysia will be undertaken.

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Table 3
SLR Present Skills

	SOFT SKILLS																				HARD SKILLS								
Sub-skills / Author	**Creativity and Critical Thinking Skill**	**Problem Solving Skill**	**Teamwork Skill**	**Entrepreneurial Skill**	**Analytical Thinking Skill**	**Research Skill**	**Intercultural Skill**	**Interpersonal Skill**	**Language Skill**	**Communication Skill**	**Self and Time Management Skill**	**Leadership Skill**	**Decision Making Skill**	**Adaptability Skill**	**Social Skill**	**Emotional Intelligence Skill**	**ICT Skill**	**Collaboration Skill**	**Ethical and Moral Professional Skill**	**Lifelong Learning Skill**	**Technical Skill**	**Computer Skill**	**IT Skill**	**Media Skill**	**Coding Skill**	**Cybersecurity Skill**	**Digital Skill**	**Robot Skill**	**Technology Skill**
Ahmad et al. [46]		/										/									/								
Azmi et al. [47]	/	/	/							/		/							/								/		
Azmi et al. [48]			/	/					/	/												/							
Canetta et al. [49]																											/		
Carter [50]	/									/							/							/					
Chenoy et al. [51]	/	/																											
Choi [52]		/	/					/				/																	
Chromjakova [53]																											/		
Ciolacu et al. [54]														/															
Erol et al. [55]	/	/	/																										
Freddi [56]																											/		
Grzelczak et al. [57]	/	/								/		/	/		/						/								
Hecklau et al. [58]	/	/		/	/		/		/	/		/	/								/			/	/	/			
Hidayat et al. [59]	/	/																											
Ismail and Hassan [60]																					/								
Karre et al. [27]			/							/	/			/	/								/		/				
Kusmin et al. [61]										/																			
Mourtzis [62]																/													
Perini et al. [39]			/							/																			

Table 3 (continued)
SLR Present Skills

	SOFT SKILLS																				HARD SKILLS								
Sub-skills / Author	**Creativity and Critical Thinking Skill**	**Problem Solving Skill**	**Teamwork Skill**	**Entrepreneurial Skill**	**Analytical Thinking Skill**	**Research Skill**	**Intercultural Skill**	**Interpersonal Skill**	**Language Skill**	**Communication Skill**	**Self and Time Management Skill**	**Leadership Skill**	**Decision Making Skill**	**Adaptability Skill**	**Social Skill**	**Emotional Intelligence Skill**	**ICT Skill**	**Collaboration Skill**	**Ethical and Moral Professional Skill**	**Lifelong Learning Skill**		**Technical Skill**	**Computer Skill**	**IT Skill**	**Media Skill**	**Coding Skill**	**Cybersecurity Skill**	**Digital Skill**	**Robot Skill**	**Technology Skill**
Pinol et al. [63]			/						/			/		/															/
Pinzone et al. [64]																						/							
Ramirez-mendoza et al. [65]																							/						
Richert et al. [66]		/																											
Sakuneka [67]										/																			
Sari et al. [68]	/	/											/																
Schallock et al. [69]															/							/						/	
Siddoo et al. [70]	/	/	/		/				/	/				/						/				/				/	
Suastra et al. [71]	/	/																											
Teng et al. [72]	/		/					/		/	/					/													
Vila et al. [73]										/																			
Total	**11**	**12**	**9**	**2**	**2**	**-**	**1**	**2**	**4**	**12**	**2**	**7**	**3**	**4**	**3**	**2**	**1**	**-**	**1**	**1**	**-**	**6**	**2**	**2**	**2**	**2**	**1**	**6**	**-**	**1**

Table 4
SLR Future Skills

	SOFT SKILLS																				HARD SKILLS								
Sub-skills / Author	**Creativity and Critical Thinking Skill**	**Problem Solving Skill**	**Teamwork Skill**	**Entrepreneurial Skill**	**Analytical Thinking Skill**	**Research Skill**	**Intercultural Skill**	**Interpersonal Skill**	**Language Skill**	**Communication Skill**	**Self and Time Management Skill**	**Leadership Skill**	**Decision Making Skill**	**Adaptability Skill**	**Social Skill**	**Emotional Intelligence Skill**	**ICT Skill**	**Collaboration Skill**	**Ethical and Moral Professional Skill**	**Lifelong Learning Skill**		**Technical Skill**	**Computer Skill**	**IT Skill**	**Media Skill**	**Coding Skill**	**Cybersecurity Skill**	**Digital Skill**	**Robot Skill**	**Technology Skill**
Carter [50]	/											/	/			/		/												
Caruso [74]																											/	/		
Chenoy et al. [51]	/	/											/			/														
Chromjakova [53]																												/		
Cicek et al. [9]	/	/	/						/	/		/	/	/		/						/		/						
Grezlczak et al. [57]																													/	
Karre et al. [27]			/							/	/			/	/									/		/				
Kusmin et al. [61]																	/													
Motyl et al. [75]																												/		
Muktiarni et al. [76]																							/				/	/		/
Sakuneka [67]																								/	/			/		
Saleh et al. [77]			/							/														/						
Shvetsova et al. [78]															/							/								
Wang et al. [79]																												/		
Total	**3**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**1**	**2**	**3**	**2**	**2**	**3**	**1**	**1**	**-**	**-**	**-**	**2**	**1**	**4**	**1**	**1**	**2**	**6**	**1**	**1**