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Research paper

Literature Review: Some of TVET Area Will Be Eliminated Due to Industrial Revolution 4.0, is That True?

Vici Syahril Chairani[1]*, Mochamad Bruri Triyono[2], Asnul Dahar Minghat[3]

[1]Vocational and Technology Education, Postgraduate Program, Yogyakarta State University, Indonesia
[2]Faculty of Engineering, Yogyakarta State University, Indonesia
[3]Razak Faculty of Technology and Informatics, University of Technology Malaysia, Malaysia
**Corresponding author E-mail: vicisyahril20@gmail.com*

Abstract

The 4.0 industrial revolution that began to be known since 2011 in Germany had a significant influence on several aspects of the world. Automation and digitilization that comes through Industrial Revolution 4.0, forecasted will brought many impact to demand and skillset of occupation and industry. Even that change is expected to have a lot of impact on Technical Vocational Education and Training (TVET). As a vocational education that has the main objective to prepare graduates to be able to work and be accepted in the industrial world. The aim of this study firstly is to provide a view of the issue about job lost due to the industrial revolution 4.0, is true or not. Secondly is to give an overview about the TVET area that have most possibility impact to be eliminated due to industry 4.0. To overcome this, this paper will explain a literature study from journal articles, opinion papers, conceptual papers, research study, etc. were analyzed for content related to Industrial Revolution 4.0 and TVET. It was concluded that (1) Occupation will be transformed by automation due to Industrial Revolution 4.0, not eliminated; (2) There is no certainty about which areas on TVET will be lost, but the areas that have the risk of being automated in TVET high school in Indonesia are administration, tourism and health.

Keywords: *TVET; Industrial Revolution 4.0; Manufacturing, Robotics; Artificial Intelligence; Smart Factory.*

1. Introduction

The 4.0 industrial revolution that began to be known since 2011 in Germany had a significant influence on several aspects of the world. One result is the digitization and automation of work, this has an important influence on economic growth, business, social life and the world of work. There will be many significant changes to the need for the world of work and industry. These changes might lead to changes in many current occupations [1]. Technical Vocational Education and Training (TVET) is one of the fields that might have many impact due to industrial revolution 4.0. As a Vocational School or education and training school that prepares people to be able to have knowledge, skills and good attitudes to work, TVET must be able to harmonize the needs of the world of work and the quality of graduates. There must be relevance between graduates produced by TVET School and the needs of the working world affected by the industrial revolution 4.0. TVET School's challenges will be increasingly complex with the presence of the industrial revolution 4.0. Without the relevance between the needs of the working world in the industrial revolution 4.0 and the quality of graduates produced by TVET School, there will be many areas or fields in TVET school that are eliminated from the needs of the workforce, so mostly it will be abandoned and no longer needed in the world of work. Future technology that we think will come in the future is already here right now such as 3D printing, robotic surgery, a robot that always win doing scissor, paper, stone game, artificial intelligence beats a go master, simulating danger, etc. [2]. Many technologies are now capable of replacing human works and this technology continues to grow, so that more and more jobs in the future can be done by machines or robots. Graduates from vocational education are one of the many workers who are threatened with this. Most graduates from TVET work a lot in the job section that mostly to be automated, so that it is very likely to be replaced by robots such as factory employees, toll gate guards, postmen, cashiers, travel agents, telephone operators and drivers. Many of the jobs mentioned earlier have been replaced by robots today. This will be very risky for graduates of vocational education in the future. To overcome this issue, it is necessary to conduct a literature study on what are the fields in TVET that might be affected by the industrial revolution 4.0 and how is the solution to overcome this. First of all, there will be a number of matters related to the industrial revolution 4.0 and their impact on various fields of work connected to vocational education graduates. Then, based on this matter, the writer will be eliminated some possibilities in TVET areas that might be eliminated if they do not make changes.

2. Literature Review

2.1. Industrial Revolution 4.0

The Fourth Industrial Revolution (Industrial Revolution 4.0) is a very widespread issue in the field of digital technology, which makes many people prepare to deal with it. The industrial revolution has so far developed in four stages, the first stage (Industrial

Revolution 1.0) commonly called power generation which was introduced in 1784, which was marked by the presence of mechanical production facilities with water and steam power. The second stage (Industrial Revolution 2.0) is known as Industrialization which began to be known in 1870 which brought significant influence on mass industrial production. The third stage (Industrial Revolution 3.0) is called the electronic era, automatic production technology and internet, the third industrial revolution used ICT (Information Communication Technologies) for automatic control of production machinery. Industrial Revolution 4.0 that still on process on going now, commonly known as introduction of digital technologies era. It takes to a qualitatively new level, which is characterised by the employment of Cyber-Physical Systems (CPS) [3]. While Industrial Revolution 3.0 focused on the automation of single machines and processes, Industrial Revolution 4.0 (IR 4.0) focuses on the end-to-end digitisation of all physical assets and integration into digital ecosystems with value chain partners [4]. The concept has launched IR 4.0 which is based on the concepts and technologies that include cyber-physical systems (CPS), data changes, automated technologies, digitized, artificial intelligence (IT), IoT, and smart factory [3, 5, 6]. CPS are defined as the systems by integrating computation, networking, and physical processes, where the embedded computers and networks control and monitor and physical processes usually in a closed-loop while the latter affects the computations and even the networks, this is also how CPS relate to the Internet of Things (IoT) paradigm [7, 3]. IoT is a self-styled term to describe objects that are able to communicate via the Internet. Objects range from sensor inputs to actuators that control physical objects with new interactions requiring advances in machine and human interfaces [8]. Based on IoT that enable perpetual communication via Internet which allows a continuous interaction and exchange of information not only between humans (C2C) and human and machine (C2M) but also between the machines themselves also between the machines themselves (M2M) [9]. IR 4.0 that also called Industrial Internet that bring concept called "IoT", bring so many impact to manufacturing industries. The successful integration of Industry 4.0 and cyber-physical systems provides significant benefits for the entire manufacturing industry. These benefits can be summarized in one term as the so-called: smart factory [10]. High levels of automation come as standard in the smart factory: this being made possible by a flexible network of cyber-physical system-based production systems which, to a large extent, automatically oversee production processes [11]. Smart factory describe as the integration of all recent IoT technological advances in computer networks, data integration, and analytics to bring transparency to all manufacturing factories [10]. Any forms of automation and digitalization brought by the industrial revolution 4.0 which led to smart technologies that applied in manufacturing, will brought many changes to the needs of the workforce, especially brought changes in the supply and demand of workforces and skillsets in the labor market [12, 13].

2.2. Technical Vocational Education and Training

Technical Vocational Education and Training (TVET) is the type of education which provides individuals with skills, knowledge and attitudes for effective employment in specific occupation [14]. According to [15], TVET is "a comprehensive term referring to those aspects of the educational process in addition to general education, the study of technologies and related sciences, and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupation in various sectors of the economic and social life". The purpose of Vocational Education is to prepare students as prospective workers and develop the existence of students, for the benefit of students, society, nation and state. Industrial Revolution 4.0 change the business models. Many of the major drivers of transformation currently affecting global industries are expected to have a significant impact on jobs, ranging from significant job creation to job displacement, and from heightened labour productivity to widening skills gaps [16]. General education as well as vocational education have a critical role to play in making employees industry ready to face Industry 4.0. They lay the foundation for skill development, which is critical for economic growth and social development of a country [17]. Overall, "Industrial Revolution 4.0" is currently seen as an opportunity by all stakeholders to make vocational education and training more attractive again [13]. Based on research by [18] conclude that more vocational skills and education will be needed to handle the more complex manufacturing facilities of the future's Industry 4.0. Because it will be needed to do maintenance tasks, identifying and solving malfunctions called for a number of vocational skills in which employees needed to have a holistic view when different technologies were merged together in manufacturing equipment. Industrial revolution 4.0 can lead to a renewed appreciation for vocational education and training as well as more attractive employment and career prospects [13]. Automation and digitalisation can become an opportunity and challenge for Vocational Education and Training (VET), as long as the system can offer the skill that need to face Industrial revolution 4.0.

3. Methodology

The research method used was a literature review that aims to give an overview about the TVET area that have most possibility impact to be eliminated due to industry 4.0. The TVET area that have most possibility to be eliminated will be known by reviewing the literature related to the research.

4. Results and Discussion

4.1. Will the Presence of Industrial Revolution 4.0 lead to Eliminate Many Jobs?

In a large-scale research that is quite popular by [19] estimated that about 47 % of U.S. employment is at risk of being automated over next decade or two. To arrive at this conclusion, they distinguish the occupation into three part, high, medium and low risk depend on probability of automation. There are 70 occupations, and they estimated whether they were automatable or not, taking into account bottlenecks to computerization in terms of tasks that cannot be easily automated with current technology (i.e., perception and manipulation, creative intelligence, social intelligence) [1]. Based on that research analysis known that a large number of jobs that work in transportation, logistic, administrative support, labour, sales, service, and production might be automated.

Other than research of [16] report that automation that overcome by Industrial Revolution 4.0 lead to a net employment impact of more than 5.1 million jobs lost to disruptive labour market changes over the period 2015–2020, with a total loss of 7.1 million jobs— two thirds of which are concentrated in the Office and Administrative job family—and a total gain of 2 million jobs, in several smaller job families. These research covered 15 economies involving 1.86 billion workers grouped into 20 job families. The research was conducted in many countries and regional organizations namely are the Association of Southeast Asian Nations (ASEAN), Australia, Brazil, China, France, Germany, the Gulf Cooperation Council (GCC), India, Italy, Japan, Mexico, South Africa, Turkey, the United Kingdom and the United States. Any research that also support data about jobs at risk cause the automation is done by [20] declare that up to 15 million jobs in the UK are at risk of automation. The author use the same methodology that use by [19], they classifies jobs in three ways in the US and UK – high (greater than 66%), medium (33-66%) and low (less than 33%) probability of automation. Occupations most at risk including administrative, clerical and production tasks. Most risky works that will be automated are the reptitive works, that did-n need creativity and thinking. Therefore, it become very possible to use programming algorithm that will enable the works to be executed or implemented by robots or artificial intelligence. In [21] find that the automatibility of jobs is lower in jobs with

high educational job requirements or jobs which require cooperation with other employees or where people spend more time on influencing others and the automatibility is higher in jobs with a high share of tasks that are related to exchanging information, selling or using fingers and hands [4].

March 2017, a widely new research by [22] that applied across the set of 27 from OECD countries plus Singapore and Russia) that use public OECD PIAAC data analysis. This study estimated the share of existing job with high risk of automation by the 2030s, is as shown below.

Table 1: Estimated share of jobs at potential high risk of automation across 29 OECD countries

Country	Risk of Automation	Country	Risk of Automation
Slovakia	44	Cyprus	30
Slovenia	42	Belgium	30
Lithuania	42	Denmark	30
Czech Republic	40	Israel	29
Italy	39	Chile	27
USA	38	Singapore	26
France	37	Norway	25
Germany	37	Sweden	25
Austria	34	New Zealand	24
Spain	34	Japan	24
Poland	33	Russia	23
Turkey	33	Greece	23
Ireland	31	Finland	23
Netherlands	31	South Korea	23
UK	30		

Source: PIAAC data, PwC analysis

This revealed a range of estimates across countries for the share of existing jobs with potential high rates of automation by the 2030s. Germany (37%), Austria (34 %), and US (38 %). Slovakia (44%) face relatively high potential automation rates, while Nordic countries such as Finland (22%) and Asian countries such as South Korea (22%) have relatively lower shares of existing jobs that are potentially automatable. In [22] identify the potential high rate of jobs to be automation in three waves, like the following table.

Table 2: Estimated share of jobs at potential high risk of automation to the 2030s in three overlapping waves:

	Waves	Description
1	Algorithm wave	Focused on automation of simple computational tasks and analysis of structured data in areas like finances, information, and communications – this is already well underway
2	Augmentation wave	Focused on automation of repeatable tasks such as filling in forms, communicating and exchanging information through dynamic technological support, and statistical analysis of unstructured data in semi-controlled environments such as aerial drones and robots in warehouses-this is also underway, but is likely to come to full maturity in the 2020s
3	Autonomy wave	Focused on automation of physical labour and manual dexterity, and problem solving in dynamic real-word situations that require responsive actions, such as in manufacturing and transport (e.g. driverless vehicles) – these technologies are under development already, but may only come to full maturity on an economy-wide scale in the 2030s

Source: PwC analysis

Eventhough, there are so many research that estimated the possibility of any occupation to be eliminated but there are also many parties oppose the results of the analysis. Some organizations criticize it such as:

1) Jobs consist of many tasks among which several might not be easily automated [20], and automation is likely to change the composition of the tasks that people perform. An estimated 60 percent of occupations have at least 30 percent of activities which could be automated with already-proven technologies. As tasks are automated, work is likely to be redefined, focusing on areas of human comparative advantage over machines. In other word, technology cannot be used as a whole and is unlikely to eliminate entire occupations, so the need for human labor in various fields will continue to exist
2) Research study by [21] found significant differences result analysis. They find average across the 21 Organization for Economic Cooperation and Development (OECD) countries, just 9% of jobs are automatable, its mean based on this research only 9% worker in the United States are working in a job that has high potential for automation, with at least 70% of performed tasks being automatable based on current technology.

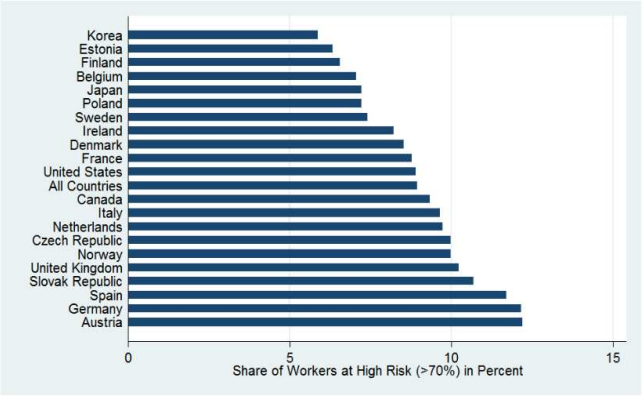

Fig. 1: Share of Workers with High Automatibility by OECD Countries [21]

The result is different contras to Frey & Osborne and PwC find that 47 % of US jobs are automatable. This research also shares the highest risk in Germany and Austria (12%), and the lowest in Korea and Estonia (6%). The number of percentages obtained differed greatly from the analysis carried out by PwC, but the range of data between countries tended to be similar, both said South Korea and Finland as countries with the lowest percentage of risk. Across countries, the researchers revealed that workers with higher educational levels and higher income were less likely to be at risk, while the majority of risk workers were low-skilled and had low income [1]. This is evidenced by the results of research conducted by [22], estimated that higher education will have low potential for automation, only 10% of the possibilities of work done by graduates from higher education are affected by automation, while low education and medium education get a higher automation risk as shown in Figure 3.

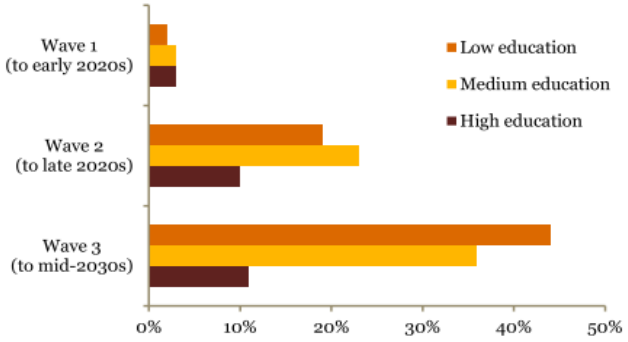

Fig. 2: Potential job automation rates by education level across waves (PwC estimates based on OECD PIAAC data, (2017))

3) Work will be transformed by automation, not eliminated. Historically, many occupations have only experienced partial automation (of certain tasks) while the number of jobs in that occupation has actually increased. This is because a particular task is automated that it can be performed more quickly or cheaply, the demand for workers to do the other non-automated tasks around it may increase [24]. This theory sounds more likely to happen, because in fact it will not be

possible for all jobs to be taken over and automated. According to [21], three reasons why risky work from technological progress cannot be equated with the loss of losing jobs are as follow :

a) The utilisation of new technologies is a slow process due to economic, legal and societal hurdles, so that technological substitution often does not take place as expected.
b) Even if new technologies are introduced, workers can adjust to changing technological endowments by switching tasks, thus preventing technological unemployment.
c) Technological change also generates additional jobs through demand for new technologies and through higher competitiveness.

In sum, the extent to which digitization and automation will lead to an overall reduction of jobs is hard to estimate and there is no consensus in the literature on the degree to which digitization and automation will affect workforce demands [1]. It is difficult to predict whether future automation and digitization will cause job losses. Which of the various research estimates that have been reviewed before the most correct, no one knows until we face ourselves with the years we estimate the automation and digilitalization comes. But one thing that is certain is that automation of the work caused by the industrial revolution will change many things in the world of work.

4.2. TVET areas that have potential risk due to Industrial Revolution 4.0

There are so many field or areas in TVET high school. According to the spectrum of vocational skills issued by the PSMK directorate of Indonesia [25]. There are 9 areas of expertise for TVET high school in Indonesia. Each area of expertise is divided into various expertise programs and expertise competencies. To be able to find out which areas of expertise in Vocational Schools that have a large potential risk will be automated (reduced market demand) due to the presence of industrial revolution 4.0, it is necessary to analyze the results of several studies related to risky jobs that will be automated because IR 4.0. On the previous page, it has been discussed that there are pros and cons between studies that estimate the percentage of jobs that might be high risk of being eliminated or automated because of IR 4.0. However, it has not been discussed what areas that have a high probability of being automated. Several studies on this have been carried out in various countries and the results are quite diverse as shown in the following table.

Table 3: Potential Job at high risk of automation

References	Type of Occupation
[19]	1. Transportation 2. Logistic 3. Administrative support 4. Labour 5. Sales 6. Service 7. Production
[8, 11]	1. Data Entry Keyers (99%) 2. Library Technicians (99%) 3. New Accounts Clerks (99%) 4. Photographic Process Workers and Processing Machine Operators (99%) 5. Tax Preparers (99%) 6. Cargo and Freight Agents (99%) 7. Watch Repairers (99%) 8. Insurance Underwriters (99%) 9. Mathematical Technicians (99%) 10. Sewers, Hand (99%) 11.Title Examiners, Abstractors, and Searchers 12. Telemarketers
[20]	1. Administrative 2. Clerical 3. Production
[22]	1. Transportation and storage (52%) 2. Manufacturing (45%)
	3. Construction (38%) 4. Administrative and support service (37%) 5. Wholesale and retail trade (36%) 6. Public administration and defence (35%) 7. Financial and insurance (30%) 8. Information and communication (28%) 9. Professional, scientific and technical (25%) 10. Accommodation and food service (22%) 11. Human health and social work (20%) 12. Education (9%)

It is difficult to summarize in general which areas of TVET will be lost due to the presence of industrial revolution 4.0. Because in essence, many jobs are automated but not eliminated (eliminated as a whole). Because each type of work has many different factors, making it difficult for work can be replaced completely by a robot or machine. But it does not rule out the possibility that over time, the jobs may be taken over completely by the machine, but it also causes the emergence of new types of jobs that require high skills that cannot be done by the machine. Most fields in high school TVET will be able to survive the industrial revolution 4.0 because according to any study that review before, we known that jobs which require high technical skills are difficult to automate. More vocational skills and education will be needed to handle the more complex manufacturing facilities of the future's Industry 4.0 [18]. But, I think not all of TVET high school will survive from high potential to be eliminated. Based on the results of surveys conducted in various types of work that have been described previously, it can be seen that the fields in TVET high school in Indonesia that are related to it, also have the same risk. Based on the literature review, we can estimate the fields in TVET high school which are at high risk will be automated due to Industrial Revolution 4.0 are as follows: (based on the spectrum of vocational skills issued by the PSMK directorate (Indonesia).

Table 4: TVET Areas that has high risk to be automated

		E
1	Administration	1. Office Administration 2. Banking 3. Marketing
2	Tourism	1. Hospitality 2. Tourism Services Business
3	Health	1. Nurse Assistant 2. Dental Assistant

These areas are based on studies that have been carried out in various countries in the past with a high risk because it is very possible to risk automation. Like most vocational school graduates who work in office administration, as we see now there are many technologies that can replace the role of office administration employees, because of the repetitive work. Vocational graduates in the banking sector who can be categorized as low-skilled, which are very easy to learn and also include repetitive types of work. We meet a lot now, employees at the bank are currently decreasing, because of the reduced need for people to come directly to the bank, because it has been facilitated by the ATM, internet banking, mobile banking, etc. However, recalling the theory presented by [23] that a job cannot be completely replaced, because every job has different complexity, and sometimes human is still needed to complete the work. For example, in bank, nowadays to save and withdraw money in the bank has been facilitated by the ATM, but when customers face obstacles such as ATM / lost savings book, borrowing large amounts of money, employess are still needed in order to give services or helps to the bank customers regarding to those cases. Because work that requires face to face meetings, and requires an analytical skill, thinking intelligence in order to find solutions and creativity to solve the problem. So, it can be concluded that the list of previously mentioned TVET fields is only at high risk of being automated and computerized, but cannot be completely eliminated from the world of work. Because it will still be needed for some kind of work that cannot be done by the machine. However, the extent of the possibility of automation will reduce the need for jobs in this field, and it will be

preferred to workers who have high-level skills who prefer not just TVET high school graduates but undergraduate who have high-level knowledge and skills, and have other possible skills needed.

5. Conclusion

Industrial Revolution 4.0 as known as the second revolution of technology brought many impacts to the world of work. Automation and digitalization enable the smart factory, IoT, artificial intelligence, robotics and smart technology, and etc. to apply in factory and production in industry. It changes the climate of demand for occupation and skillset. Although, many organizations criticize that IR 4.0 will eliminate many kinds of job, but I stand for that jobs just will be transformed by automation, and not eliminated. Because job or occupations consisting of many kinds of task, that cannot be all be automated. Even if there is automation, workers only need to adjust to the needs of the work world that they are facing, and do other types of work that cannot be automated. TVET as vocational school that has objectives to prepare graduates to have skill and knowledge that need labour market. IR 4.0 also brought many change and challenge to TVET to face it. I believe the fact that there is no certainty about which areas on TVET will be lost, but there are some areas or fields in TVET that have high potential risk of being automated. To be able to survive from risk of automation, any suggestion that must considered to TVET School should not only learn to prepare high skills that are not automated and digitized but also prepare displays other than their fields, which are supportive. Like training for public speaking, discussion, and presentation. Not only focusing on skill techniques that require high skills in a field, but also need to pay attention to knowledge, attitude, and analytical skills of thinking, and persuasive thinking to be able to survive in the world of work.

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