

Competency Demands of Vocational High School Graduates in the Era of the Industrial Revolution 4.0

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Abstract— The industrial revolution 4.0 has affected the labor market and the skills needed by the workforce. Vocational education, especially Vocational Schools, plays an important role in realizing graduates as prospective workers who are skilled and able to respond to the demands of industry 4.0. This paper aims to provide an overview of the competency map that Vocational High School (SMK) graduates must possess in responding to the demands of industry 4.0. The method used in the presentation of this paper is the literature review method from various journals published in 2017-2021. The results of the study indicate that the application of industrial technology 4.0 requires the technical education curriculum to change, resulting in new competencies both in terms of knowledge and skills that can respond to industry 4.0. In addition to skills in their area of expertise, SMK graduates must have the ability and knowledge of ICT. Meanwhile, from the aspect of soft skills, there are three main competencies that must be attached to SMK graduates, namely methodological, social, and personality competencies. This description of the knowledge and skills that must be possessed by SMK graduates is expected to provide recommendations for future curriculum changes.

Keywords—competency, skill, vocational high school, industrial revolution 4.0

I. INTRODUCTION

The Industrial Revolution 4.0 greatly affects the pattern of human life activities. Many sectors are feeling the impact of the 4.0 industrial revolution, including the education sector. One of them is vocational education which has a role in preparing students to be ready to work, both working independently (self-employed) and also filling job vacancies in the world of work [1-3]. The industrial revolution 4.0 has also affected the labor market and the skills needed by the workforce, so that there are several professions or jobs that have disappeared [4,5]. The skills and qualifications of the workforce will be the key to the success of a highly innovative factory [5]. Industry 4.0 will result in significant changes in skills development that have implications for technical education institutions [6]. The education system must consider their knowledge and ability to update and advance themselves to present and future generation Z (gen-Z) [7]. An ineffective vocational education

system results in a significant mismatch between the demand and supply of skills in the labor market. Other than that, there is increasing recognition of the mismatch between the supply of skilled labor and the demand for the workplace [8].

The potential impact of Industry 4.0 on unemployment in the future, and the need for a highly responsive education system to develop the Industry 4.0 workforce in the future [9,10]. This is in line with unemployment data based on the highest education displayed by the Central Statistics Agency (BPS) from 2018 to 2020, that in February 2020, the Open Unemployment Rate (TPT) based on the highest education completed by Vocational High School (SMK) was still the lowest. higher among other education levels (8.49 percent) [11]. This condition is a problem that needs to be solved together. One of the problems that occurs is the competency gap of SMK graduates with the world of work which has entered the industrial era 4.0. This is in line with the results of research conducted by Eka Afrina, et al [12] that the cause of the job miss match which resulted in an increase in the number of unemployed, namely vocational education and training institutions have not been able to answer the needs of the workforce, one of which is caused by the vocational education and training curriculum. not in accordance with the business world and the industrial world [12].

The vocational education system must respond to the needs and expectations of these changes in the world of work. A successful response of the vocational system to the demands of Industry 4.0 should focus on curriculum development and training for skilled and highly skilled workers [13]. Each curriculum must have components such as technical components, soft skills components, and social components, to provide competence to graduates [5]. Research conducted by Doreen McGunagle [14] that the manufacturing industry needs employees who can work well on their own, proactively and motivate themselves and with others effectively in a team, can solve problems and communicate (verbally) their solutions. propose. However, employees with a technology and engineering education background must still have technical competence to complete tasks related to certain disciplines [14].

This is one of the authors' appeals to examine more deeply the demands of competence that must be possessed by vocational education graduates. Thus, the purpose of this paper is to provide an overview of the competency demands that vocational education graduates must possess in the era of the industrial revolution 4.0. The method used in this paper is the literature review method on several articles from various journals that have been published between 2017-2021. This paper is organized into five parts, namely introduction, method, results, discussion, and conclusion.

II. METHODS

The method used in presenting this paper is by using the literature review method on various articles related to the demands of competence in the era of the industrial revolution 4.0. Generally, articles are published from various international journals and the results of proceedings are in the 2017-2021 range. The keywords used in the search for the article use several keywords that are relevant to the topics discussed, industry 4.0, future competencies, education 4.0, technical education, curriculum development, job skills, and so on. As for the details of the number of articles and their scope. The study can be seen in the table 1 below:

TABLE I. LIST OF ARTICLES RELATED TO THE DEMANDS OF VOCATIONAL EDUCATION COMPETENCIES IN THE ERA OF THE INDUSTRIAL REVOLUTION 4.0 PUBLISHED BETWEEN 2017 – 2021

Year	Number of Articles	Scope
2017	7	Workforce Competency Model, Industry 4.0 Competencies for management, Skills of future engineers, Curriculum, competencies, educational requirements and workforce qualifications
2018	7	Technical education 4.0, Industry 4.0 impact, required competencies, talent development, Frame Work of Curriculum, industry 4.0 framework, competencies
2019	7	Development of the TVET system, technical education, industry 4.0 skills requirements, the impact of industry 4.0 on the workforce, jobs and skills in industry 4.0, redesign of the curriculum according to industry 4.0
2020	8	Continuing Education in Industry 4.0, curriculum 4.0, competency development models, work skills, the impact of industry 4.0 on mining, competencies, skills and literacy, competencies for industry 4.0,
2021	2	Competency development, competency mapping
Total	31	

III. RESULTS

A. Industrial Revolution 4.0

Industry is affected by technological change and innovation. This paradigm is called the industrial revolution. After Germany launched a project to digitize manufacturing at the Hannover Messe in 2011. Since then the term "Industry 4.0" has come into widespread use [9]. The technology integration that is emerging today is becoming a radical transformation of the industry called industry 4.0. Industry 4.0's

goal is to enable smart factories to produce personalized output by leveraging greener, more efficient, flexible and individual processes that are fully digitally controlled or even self-managed [15,16]. The fourth industrial revolution and its underlying digital transformation, known as Industry 4.0, is growing exponentially. The digital revolution is fundamentally reshaping the way individuals live and work, and the public remains optimistic about the opportunities Industry 4.0 offers for sustainability [17].

The main vision of this revolution is the emergence of smart factories. In the smart factory, the virtual world will be connected with the physical reality world. A cyber physical system called CPS will be used to connect machines at the factory. Nine basic technologies (Autonomous Robots, Augmented Reality, Simulation, Vertical and Horizontal Integration, Cybersecurity, Internet of Things, Big Data, Cloud Computing and Additive Manufacturing) will be the building blocks of this factory. These nine technology trends will transform production into a fully integrated, automated and optimized production flow [18,19] (see figure 1).

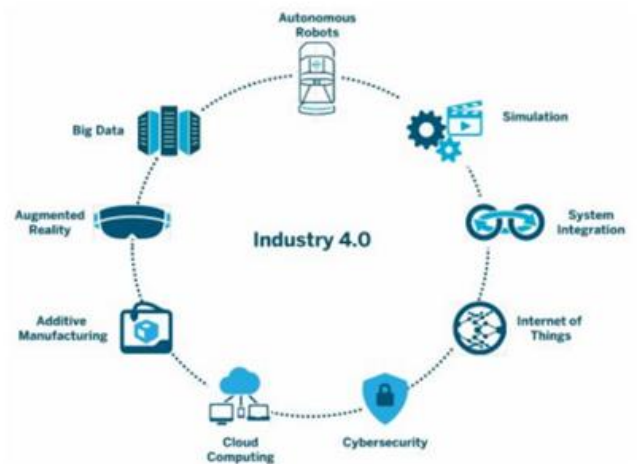


Fig. 1. Nine basic technologies of industry 4.0 [15]

B. Industry Impact 4.0

Industry 4.0 can be said as a paradigm shift that aims to encourage digitalization, networking and virtualization in industry in all fields. As a result, in addition to Industry 4.0 the terms Economy 4.0, Work 4.0 and Learning 4.0 are the subject of intensive political-industrial discussion. These discussions explore the possibility of increasing digitization, to the impact of digitization on jobs, qualifications, the world of work, mobility, productivity, work safety and so on [16]. Emergence of Industry 4.0 and smart factories along with all enabling technologies like cloud computing, Internet of Things, multi-agent systems, cyber physical systems, artificial intelligence, etc. Will turn current factory workers into knowledge workers. Hard work and routine tasks will be carried out by machines or robots, while tasks that require experience, intuition, creativity, or decision making based on uncertainty will remain the responsibility of humans [17].

Increasing labor productivity and significant changes in the labor market as a result of the 4.0 industrial revolution will affect the education system, because the quality of graduates is very important to face smart factories in the future [18]. Education 4.0 is a term that is the starting point for overhauling the education system, to meet the workforce needs of the talents needed that can be changed. Education 4.0 is projected to be a new era that integrates technology into almost all elements of pedagogical education. Students are expected to be able to innovate how to become a source of knowledge and the learning process can be done anywhere and anytime [19].

The impact of Industry 4.0 is not only from the workforce, education, but also has an impact on the type of work. The loss of various types of jobs (and skills) as well as the emergence of new jobs (and skills) in Industry 4.0 is a

challenge for vocational education to be able to produce graduates who are able to enter the rapidly changing world of work [19]. all work can be broadly grouped as routine or non-routine, and cognitive or manual. Routine tasks include a standardized, limited, and well-defined set of cognitive and manual tasks; non-routine tasks do not include standard tasks. Cognitive (or abstract) tasks demand complex problem solving, judgment, creativity, and/or people interactions; manual tasks require situational adaptation, visual and/or language recognition, and hands-on interaction [9,20]. Every the prospective increase in the number of jobs with routine tasks will be replaced by new technologies and will eventually result in mass unemployment [9].The following are some search results articles that examine the impact of the industrial revolution on education and employment (table 2):

TABLE II. ARTICLES EXAMINING THE IMPACT OF INDUSTRY 4.0 ON EDUCATION AND EMPLOYMENT

No	Year	Writer	Research purposes	Research methods	Research result
1	2018	Sumer, Beyza Prof, Asst	Highlight changes prospective in employment and job loss due to new technology in Turkey	The methodology of this paper is hypothetical which is supported by empirical data obtained from the Turkish Statistical Institute (TUIK), Household Labor Force Survey, from 2001 to 2017 January	There are considerable disadvantages in some categories of work with routine tasks, in both manual and cognitive work. In some other occupations, new technologies have complementary effects that may lead to job creation.
2	2019	Elmi Achelia, Indri Juwita Asmara, and Nani Grace Berliana	Assessing the anticipated impact of facing Industry 4.0 on the Indonesian labor market	Analysis of data from the Central Statistics Agency (BPS), Indonesia	It is necessary to improve the quality of the main workforce by improving the quality of education. The government also needs to ensure a link and match between supply from education and demand in the labor market
3	2019	Andrea Benesova, Martin Hirman, Frantisek Steiner and Jiri Tupa	Describe the qualification requirements of employees in Industry 4	<ul style="list-style-type: none"> Literature Review Interview Brainstorm 	Qualified employees will be the key to the company's success in the future. For this reason, the educational framework will be a very important part of the Industry 4.0 concept.
4	2020	Georg Spöttl & Lars Windelband	Identify changing competency demands as a result of Industry 4.0	<ul style="list-style-type: none"> Qualitative survey Interview Case study 	Employee qualifications depend on the level of implementation of Industry 4.0 in the company, Vocational education and training for the workforce is highly relevant and the vocational education system must respond to the needs and expectations of these changes in the world of work. Industry 4.0 demands must focus on curriculum development and training for skilled and highly skilled workers.
5	2020	Mita Brahma and Shiv S. Tripathi	Introducing the framework used in the program for work executives, designed to prepare them for the industry 4.0 digital work environment.	Adopt a case-based approach	The digital workplace presents challenges such as job fragmentation, disconnection between team members, uncertainty about the assessment of efforts as well as the assessment of outputs
6	2018	Leni Rohida,	Explaining the influence of the industrial revolution 4.0 era on human resource competence.	<ul style="list-style-type: none"> Participatory qualitative research methods The data were obtained through a literature study of interviews and direct practice. 	Competence concerns a person's characteristics related to how to perform effectively and have an advantage in a particular job. the need for employee competence is not only limited to technical matters. But also related to non-technical skills. Competence and performance issues are fundamental problems faced by employees. competence and performance have a very close relationship

C. Required Competencies

Based on the research conducted by Kipper et al [21] related to the skills needed by industry 4.0 based on the groups of “skills”, “technical education”, and human performance, a

concept map was compiled, namely hierarchical diagrams and dimensions that show the structure of knowledge in context. certain. The concept map of these skills and knowledge to highlight the mainstream of transformation caused by the application of technology [21].

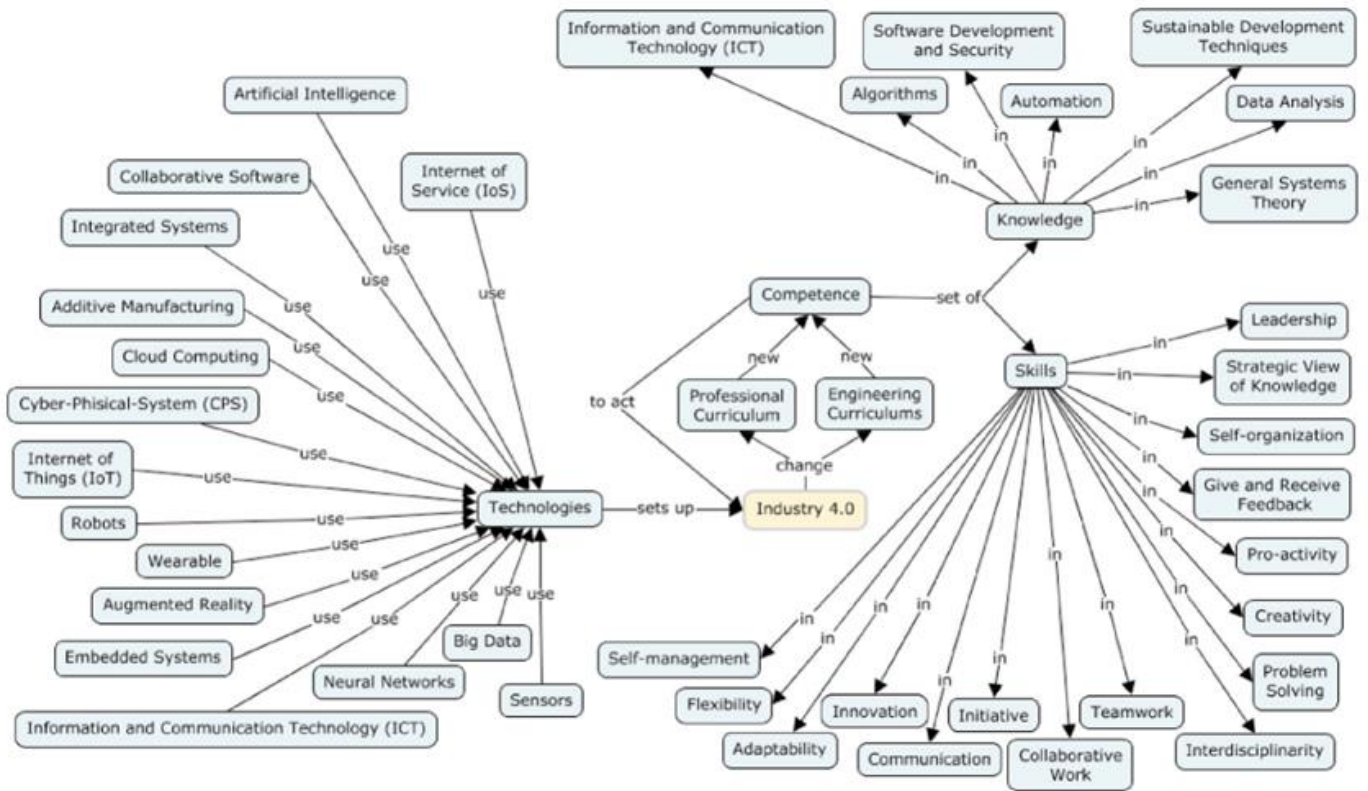


Fig. 2. Conceptual map of transformation for industry 4.0 [21]

Figure 2 shows that the application of technology in the industrial era 4.0 will change the professional and engineering curriculum, so that it will produce new competencies, both skills and knowledge. In line with the results of the study, the competencies needed by the workforce in the industrial era 4.0 include technical competence, methodological competence, social competence, and personal competence [22]. The details of these competencies are as follows (table 3):

TABLE III. COMPETENCIES REQUIRED FOR INDUSTRIAL WORKERS 4.0

No	Competency Type	Competence
1	Technical competence	State-of-the Art knowledge, technical skills, understanding processes, media skills, coding skills, and understanding IT security.
2	Methodological competence	creativity, Entrepreneurial thinking, Problem solving, conflict solving, Decision making, Analytical skills, Research skills, Efficiency orientation
3	Social competence	Intercultural skills, Language skills, Communication skills, Networking skills, the

		ability to work in a team, the ability to compromise, the ability to transfer knowledge, and leadership skills.
4	Personal competence	Flexibility, Ambiguity tolerance, Motivation, ready to work under pressure, sustainable mindset, compliance

In line with the above competencies, the World Economic Forum (WEF) has strengthened the soft skills ability, by reporting that in the next five years there will be 10 skills that will remain and continue to grow in the era of growing influence of technology adoption, namely: 1). Analytical thinking and innovation, 2). Active learning and learning strategies, 3). Complex problem solving, 4). Critical thinking and analysis, 5). Creativity, originality, and initiative, 6). Leadership and social influence, 7). Use, monitoring and control of technology, 8). Technology design and programming, 9). resilience, stress tolerance, and flexibility, and 10). Reasoning, problem solving and ideas [23]. The skills above include 21st century skills, such as communication, innovation, creativity, problem solving, collaboration, critical

thinking, and decision making [24]. According to the BRICS Skill Development Working Group the skills required in Industry 4.0 are applied and technical skills (such as basic knowledge of ICT, data analytics, etc.), it is important for the workforce to have basic skills on equipment operation and problem solving, able to adapt and learn new skills [25].

Digital skills are also a demand for the workforce, because digitalization is the fundamental basis for Industry 4.0. Don't let the "digital divide" occur between companies, workers, users, and other collaboration partners in implementing this digitalization [26]. Another study found that outside of work skills, foreign languages (especially English), communication, and ICT skills are the skills most expected by the world of work for graduates of colleges/technical schools in Indonesia [27].

IV. DISCUSSION

Vocational education has a role to prepare skilled workforce candidates in accordance with the demands of the world of work, including vocational high school graduates. Not only ready to become a skilled workforce, but able to work independently or as an entrepreneur. Industry demands on prospective workers will continue to increase in accordance with developments in the application of technology in the world of work. The industrial revolution 4.0 has had an impact on various sectors, including the education and employment sectors. There are nine technological trends that change the production process in the industry to be fully integrated, automated, and optimized through digitization with the application of cyber physical system (CPS) technology, so that the realization of a smart factory. The nine technologies are Autonomous Robots, Augmented Reality, Simulation [18].

The impact of industry 4.0 on the education sector can be felt both from the learning process and curriculum [16]. Learning can be done anywhere and anytime, even students can innovate how to become a source of learning [19]. The vocational education curriculum must be able to adapt to the demands of the world of work, so it is necessary to develop a vocational education and training curriculum that can improve the competence of the workforce to respond to industry 4.0. In line with the opinion of Maisiri et al, that the curriculum must be appropriate to address problems and prepare students to be competent in the digital economy [6]. According to research by Rizwan Matloob Ellahi, et al, there are five main aspects in industry 4.0 and become focus areas to consider in developing and designing higher education curricula that are in accordance with the current industry, namely Big Data, Internet of Things, Cloud Computing, Artificial Intelligence, and Augmented Reality [7]. This is a consideration in developing the vocational education curriculum by strengthening digital/ICT skills for students, and encouraging teachers to improve their ICT skills.

The industrial revolution 4.0 also has an impact on employment, both in terms of type of work and workforce profile. Some jobs or competencies are lost and new jobs are created, so this becomes a challenge as well as an opportunity

for prospective workers and vocational education [9,19]. Responding to rapid changes due to the application of industrial technology 4.0, vocational education needs to examine more deeply related to competencies and types of work that will survive and continue to grow, especially for vocational high school (SMK) graduates, as input and improvements to competencies that are appropriate to be studied for graduates. SMK.

Industry 4.0 also has an impact on competency demands for the workforce profile, so that new competencies both knowledge and skills emerge. There are four types of competencies needed in the era of the industrial revolution 4.0, namely 1). Technical competence, 2). Methodological competence, 3). Social competence, and 4). Personal competence [22]. Vocational High School graduates must be able to have technical competence in accordance with their respective expertise and be strengthened by ICT skills. Meanwhile, methodological, social, and personal competencies are soft skills competencies and are reinforcement of 21st century skills. The World Economic Forum has reported that in the next five years there are 10 skills that will remain and continue to grow in the era of the influence of technology adoption that continues to grow, namely: 1). Analytical thinking and innovation, 2). Active learning and learning strategies, 3). Complex problem solving, 4). Critical thinking and analysis, 5). Creativity, originality, and initiative, 6). Leadership and social influence, 7). Use, monitoring and control of technology, 8). Technology design and programming, 9). resilience, stress tolerance, and flexibility, and 10). Reasoning, problem solving and ideas [23].

A. Durmus and A. Dağlı also provides reinforcement that the expectations of the Industry 4.0 workforce are the use of technology, knowledge competence, motivation to learn, problem solving, cooperation, teamwork, easy adaptation to change, agility, and others [28]. The demand for workforce competence demands that the vocational education curriculum must contain multiple competencies, namely: 1) Critical thinking, problem solving, collaboration, and creativity and innovation, 2) Digital literacy skills include information literacy, media literacy, and ICT literacy, and 3) Career and life skills include flexibility and adaptation, initiative, social and cultural interaction, productivity and accountability, leadership and responsibility [24,29]. This competency profile is needed to live in the XXI century and the industrial era 4.0 [3]. Competency demands for vocational education graduates, especially SMK, must be adjusted to the Indonesian National Qualifications Framework (KKNI), where SMK graduates are at level 2, namely as operators [30].

V. CONCLUSION

Vocational education graduates, especially Vocational High Schools who are prepared to become candidates for employment and entrepreneurship must have multiple competencies, to be ready to respond to the challenges and demands of industry 4.0. These competencies include technical competence, methodological competence, social competence,

and personal competence. These competencies already include 21st century competencies. In addition, SMK graduates must have basic ICT/Digital skills and knowledge, because digitalization is fundamental for industry 4.0. These competencies must of course be adjusted to the KKNI level, where SMK graduates are at level 2, namely as operators. The impact of the current demands for the competence of prospective workers, becomes a consideration and input for the development of a vocational education curriculum, especially SMK, in order to be able to respond to the demands of industry 4.0.

The study in this paper has limitations, namely that the study is still too broad, so further research is needed to find out specifically the demands of competence according to the field and level of the IQF. In addition, there needs to be a direct study into the world of work on the demands and profiles of the workforce needed according to the field of expertise in the era of the industrial revolution 4.0

ACKNOWLEDGMENT

The author would like to thank the Lembaga Pengelola Dana Pendidikan (LPDP) - Ministry of Finance of the Republic of Indonesia which has provided support and assistance for educational costs to the author to complete his master's education.

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