Teaching Factory Management in the Industrial Era 4.0 in Indonesia

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Abstract

The emergence of the industrial era 4.0 led to the need for changes in the world of education to compensate for the increase in this industry. Teaching factory learning itself has a function to be able to prepare graduates who the industry can immediately absorb. To see the success of the teaching factory, a comprehensive evaluation is needed so that the strengths and weaknesses of the teaching factory can be known. This study uses a descriptive approach based on a literature review. The research data were obtained from various research results and previous studies still relevant to this research. From the results of this study, it was concluded that the implementation of the teaching factory was still not running correctly because there was no common understanding regarding the teaching factory learning pattern among the parties concerned. In addition, there are limitations in resources, so as a result, schools have difficulties implementing optimal teaching factories.

Keywords: *Indonesia, Industry 4.0, Teaching Factory.*

A. INTRODUCTION

Education is one of the valuable tools to increase the creativity and potential of students to face the challenges of industry 4.0 in the framework of developing quality and dignified human resources. The philosophy of education must be understood by students so that when they enter the world of work or society, graduate students can implement and develop their potential with dignity (Rahmatullah et al., 2022).

Looking at the data from the Central Bureau of Statistics regarding the State of Indonesia's Employment in February 2018 No. 42/05/Th. XXI, 07 May 2018. In February 2018, the Open Unemployment Rate (TPT) was 5.13 percent, and judging from the education level, the TPT for Vocational High Schools (SMK) turned out to be the highest percentage among other education levels which was 8.92 percent (Hidayat et al., 2019).

According to Herminarto, Teaching Factory is an attempt to present the real world of work in an educational environment. This teaching factory aims to increase student competence, increase the entrepreneurial spirit of graduates, produce value-added products (goods/services), increase school income, and increase cooperation with business/industrial companies (Maryanti et al., 2020).

The 2013 curriculum was created to face the challenges of industry 4.0 and the demands of building quality and dignified Indonesian human resources. The emphasis of the 2013 curriculum is to improve the mindset, improve the curriculum, deepen and develop materials, improve the quality of learning methods, and adjust material needs so that they can produce the expected outcomes. For this reason, a scientific approach is needed through research so that it can apply learning methods that encourage solutions. Teaching factory is part of learning that encourages students to provide solutions to the needs of the industrial and business worlds that have used technology a lot (Bagley et al., 2020).

The teaching factory paradigm, according to Mavrikios, strives to integrate manufacturing education and training with the requirements of contemporary industrial practice. Future engineers and professionals must be taught with a new curriculum to meet the rising demands of the manufacturing business in the future. The teaching factory paradigm comprises of pertinent educational methodologies and the setup of information technology required to support industry and education interaction. Teaching Factory seeks to facilitate two-way transmission of knowledge between education providers and industry. The two knowledge channels of the paradigm are given in the context of real-world industrial applications in this book. Teaching Factory provides students with a realistic setting in which to develop their abilities and comprehend the challenges of everyday industrial activity (Salah et al., 2019).

Seeing how a new era has come with the theme of Industry 4.0, education must change its educational strategy. According to Mortzis, one of the areas that has been so heavily affected is the manufacturing sector. Manufacturing in this era has moved to the digitalization phase. Industry 4.0, enabled by breakthrough technologies such as the Internet, Cloud technology, and Virtual Reality, will play a crucial role in manufacturing education, facilitating the advanced lifetime training of a competent workforce. Further education, also known as Education 4.0, and the environment will also have an impact on the development of new manufacturing-era skills and capabilities. Adopting cyber-physical systems and Industry 4.0 technology in accordance with the Teaching Factory Paradigm will restructure education to meet the rising demand for highly trained workers (Mian et al., 2020).

The industrial 4.0 era is steadily permeating today's manufacturing processes, while research increasingly focuses on future integration possibilities. Industry 4.0 introduces revolutionary manufacturing technologies that propose new connection and data management (Cloud Technologies) and new venues for knowledge sharing and training (Augmented and Virtual reality) that are increasingly integrated into production. This initiative is reconfiguring industrial equipment and upgrading them to cyber-physical systems (Galati & Bigliardi, 2019).

Manufacturing education may rely heavily on the same technology. This crucial enabling technology permits the successful transfer of information to the future workforce, so establishing a sophisticated new framework for industrial education. The 4.0 education system intends to raise the number of new and experienced workers in order to expedite the creative proposals of Industry 4.0, hence establishing a sustainable environment that will speed up its implementation in the industrial sector (Maddikunta et al., 2022).

Through the brief explanation above, the researcher then intends to examine how the implementation of the teaching factory is exemplary and correct in Indonesia and its obstacles.

B. LITERATURE REVIEW

1. Teaching Factory

According to Sudiyanto, a teaching factory is a student learning activity in producing goods/services in the school environment. Teaching factory is the concept of presenting the world of work or industry in the school environment to prepare competent graduates for employment. Hadlock explained that the teaching factory aims to make schools aware of being able to provide what is in the book but also be able to work together in teams, have communication skills, and have experience entering the industrial/work world (Dewi & Sudira, 2018).

From the preceding definition, it can be deduced that the teaching factory is an integration of competency learning and production, in which the teaching and learning process in schools is conducted in a manner similar to the real world of industry/work by delivering services and producing goods. Products (goods or services) produced have good quality and can meet consumer needs. There are several indicators for the implementation of teaching factories in Indonesian schools, for example, in vocational high schools (SMK), including in learning activities: the skill learning process is designed based on actual work standards, and the situation is made similar to the actual work situation, problem-solving orientation, orientation learning for students, learning by doing, focusing on competency achievement, soft skill development, continuous learning, teaching factory socialization, constant and steady evaluation of the teaching factory (Vidiastuti & Purwonto, 2021).

According to Sri, the standard application of the learning model factory learning focuses on three elements: students, teachers, and management. Seven parameters are defined by the Technical and Vocational Education and Training (TVET) as the standard assessment criteria to assess the implementation of factory teaching. The seven parameters are Management, Laboratories, Learning Patterns, Marketing Campaigns, Products/Services, Human Resources, and Industrial Relations. The target of achieving learning outcomes following factory teaching and learning is character development, hence the character needed in business and the industrial world. In addition to having hard skills, students are also expected to have soft skills, namely: (a) motor skills, including the ability to interact socially, be intimate, be energetic, and be creative; (b) cognitive/knowledge, including the ability to understand, implement, analyze, develop concepts or schemas, and be innovative; (c) affective/attitude, including the ability to have an independent attitude, integration, and to be intuitive (Antony, 2018).

According to Martawajaya, the implementation of the teaching factory learning model described by the 6 Steps Factory Teaching model begins with an implementation preparation and is followed by three main stages of activity, namely: introduction, main stages, and evaluation. After that, Martawajaya stated that the concept was to teach factories to bring an industrial climate to schools. The factory teaching implementation learning model starts with preparing lesson plans (RPP) or syllabus (SAP) and managing learning schedules by combining conventional programs, block systems, and continuous learning. Dimitris presents the Teaching Factory concept through the utilization of innovative distribution mechanisms and high-quality industrial equipment for instructional content (Supriani et al., 2022).

Dimitris also described the investigation of Holograms as a vital tool for delivering educational content in the classroom. The holographic system enables the visualization of complex 3D models in actual scale, allowing the student team to simultaneously view the model in 3D. A prototype offering collaboration options for both sides of the Teaching Factory environment has been implemented. Laboratory interaction is possible using device-based gesture recognition (Nadila et al., 2021).

Teaching Factory is presented by Dimitris, Konstantinos, and George as a knowledge delivery system that provides a paradigm shift to industrial education. The concept and execution of the paradigm are presented. In conjunction with the industry, several pilot applications demonstrate its potential. Teaching Factory Network (TFN) is proposed as a higher network-based paradigm for manufacturing education, connecting training demand and supply within a network of industrial and academic/research participants (Sepasgozar, 2021).

According to Rentzos, the foundation of Teaching Factory is knowledge. The triangle concept intends to create a new paradigm for academic and industrial education. Its objective is to provide students with hands-on engineering and practical activities in industry settings, drawing on research and industrial learning activities for engineers and managerial levels. Research, education, and innovation are the three main and highly interrelated drivers of knowledge-based civilizations. Teaching Factory strives to incorporate all three pillars into a single project to promote manufacturing-based, competitive, and sustainable knowledge for the future. Teaching Production is an emerging concept that claims to combine the factory environment with the classroom (Aljinovic et al., 2021).

Evaluation is needed to determine the level of success in a learning process. From the evaluation, it can be seen whether the educational program has achieved the goals that have been made previously. According to Arikunto, evaluation is an activity to collect information about the workings of something, then that information is used in determining alternatives in the decision-making framework. As Rogers said, evaluation is gathering and analyzing data to form an assessment based on solid evidence (Carvalho et al., 2019).

From the opinions above, it can be concluded that evaluation is an activity to collect information from a program and see the level of success, then it is used to improve things that are still not good and maintain things that are considered good (Yeager et al., 2019).

In Sri's research, the evaluation model used is a CIPP model. CIPP is a set of information which activities, characteristics, and a systematic summary of the outputs of a program used by certain people. CIPP is aimed at evaluating and reducing failures, increasing effectiveness, and making decisions related to the program to be carried out, including its impact. The CIPP model used in this study is the CIPP model in Indonesia, whose process orientation consists of four CIPP components: context evaluation, input evaluation, process evaluation, and product evaluation. The CIPP evaluation is presented as a factory teaching framework regulatory model starting from planning, implementation, and evaluation (Salehi et al., 2021).

The evaluation criteria for all components are adjusted to the raw parameters the TVET institution sets. At the same time, the evaluation criteria for teaching activities are adjusted to the 6 Steps from the Teaching Factory found by Martawajaya. That is the standard for implementing Teaching Factory related to production, using the criteria set by the Decree of the Minister of Industry and Trade of the Republic of Indonesia Number 705 / MPP / Kep / 11/2003 concerning industrial engineering requirements of bottled water drinks and their trade. The context evaluation component identifies factory teaching needs and institutional needs for factory teaching. The input evaluation component provides a reference for preparing the Teaching Factory implementation so that it will follow the standards. The component process evaluation monitors the performance of the Teaching Factory and procedural obstacles that occur during implementation, as well as identifies the need for adjustments to the implementation of the Teaching Factory. Evaluation of component products identifies and assesses the results of Teaching Factory implementation (Spottl & Windelband, 2021).

2. **Industry 4.0**

Industry 4.0 is another word for the industrial revolution 4.0. Regarding the history of the industrial revolution, Rojko and Xu say that the first industrial revolution (industry 1.0) began with mechanization and mechanical power generation in the 1800s. This brought about the transition from manual work to manufacturing processes using the steam engine (the age of the steam engine), mainly in the textile industry. Industry 2.0 started in the 1900s and is referred to as the electrical and industrial age. Industry 3.0 started in the 1960s, during the information age, digitalization, and electronic automation. Industry 4.0 is the age of cyber-physical systems or intelligent automation (Da Costa et al., 2019).

Bahrin believes that the industrial sector is vital to any nation's economy and is a key generator of economic growth and jobs. In this perspective, industry, which focuses on manufacturing, delivers added value by transforming raw resources into finished goods. The phrase industry 4.0 was introduced to the general public in 2011 by an effort called industry 4.0, in which associations of commercial, political, and academic leaders supported the concept as a strategy to enhance the competitiveness of the German manufacturing sector. Germany is a global leader in the manufacturing equipment sector and has one of the most competitive manufacturing businesses in the world. Since the German federal government identified industry 4.0 as one of the primary projects of its high-tech strategy in 2011, the issue of industry 4.0 has been widely known among businesses, research institutions, and universities (Anshari & Almunawar, 2021).

In addition, Rojko stated that the fundamental notion of industry 4.0 was initially introduced during the 2011 Hannover fair. Industry 4.0 has been a topic of discussion in the research, academic, and industrial communities on multiple times since its debut in Germany. Then Xu concurs that industry 4.0 was first introduced during an expo in Hannover in 2011; moreover, it was formally announced in 2013 as Germany's strategic initiative to play a pioneering position in the industry that is currently altering the manufacturing sector (Culot et al., 2020).

Industry 4.0 is a new field in which the internet of things and cyber-physical systems are interconnected in such a way that the combination of software, sensors, processors, and communication technologies plays a significant role in the creation of something that has the potential to store data and ultimately add value to the manufacturing process. This is also consistent with Rojko's view, according to which industry 4.0 aims to utilize the potential of new technologies and concepts, such as the internet, integration of technical and business processes in companies, digital mapping, and virtualization of the real world, and smart factories consist of smart production facilities and smart products (Angelopoulos et al., 2019).

According to Bahrin, the technologies related to industry 4.0 are as follows: The Internet of Things (IoT) serves to connect all computing devices using certain technologies. Allows devices to communicate and interact with each other with centralized control. It is also helpful in analyzing and making decisions in real-time. Cybersecurity, reliable communications, enhanced identification, and machine and user access control are required for industry 4.0 in order to combat the cybersecurity threats that are escalating significantly due to an increase in connection and communication protocol standards. The cloud, improving technology performance, data and functionality are then deployed to the cloud in order to provide production systems with more data-driven services (Lee & Lim, 2021).

Industry 4.0 will necessitate greater data exchange between enterprise sites for a greater number of production-related firms. Big data analytics provides exhaustive data gathering and evaluation from numerous sources and customers to assist direct decision making, maximize manufacturing quality, conserve energy, and enhance equipment service. Integration of horizontal and vertical systems as cross-company, universal data-integration networks expand and enable totally automated value chains, horizontal and vertical system integration will become more cohesive among businesses, departments, functions, and capabilities. Augmented reality can facilitate the selection of spare parts at warehouses and the transmission of maintenance instructions via mobile devices. Additive manufacturing (also known as 3D printing) may create a variety of customized items, including those with intricate patterns, low weight, excellent performance, and reduced haulage and inventory lengths. Using real-time data, the simulation creates a virtual representation of reality that includes machinery, products, and people. This permits the operator to test and adjust tool settings for subsequent production, thereby lowering tool setup time and enhancing product quality. Robots are more autonomous, adaptable, and cooperative; they interact with one another, can operate securely with humans, and can learn from them. Robots are less expensive and more versatile than humans (Sun et al., 2020).

C. METHOD

This study uses a literature review method. Researchers look for journals about teaching factories in google schoolar. Several journals were found using the key word evaluation, teaching factory and vocational schools that discussed this material. Of the many journals found, the researchers only took a few that had discussions directly related to evaluating the implementation of teaching factories in schools in Indonesia. In addition, researchers are also looking for teaching factories following the industrial era 4.0 and the technology used to support the effectiveness of teaching factories in the world. From several journals that carry technological developments in the development of teaching factories, it is easier for researchers to evaluate teaching factories in Indonesia.

D. RESULT AND DISCUSSION

1. Exemplary Implementation of Teaching Factory in Indonesia

The implementation of the teaching factory can run appropriately if it has previously been well informed about the teaching factory learning pattern to related parties such as educators, education staff, students, parents/guardians of students, and school partners, to reach an understanding and establish practical cooperation. However, there are often obstacles regarding this in implementing these activities. In addition, due to limited resources (capital and experts), not all schools can carry out this teaching factory optimally, but they try to continuously improve the quality of the teaching factory gradually and constantly until it reaches the expected point.

Problems in the industry can encompass various phases of the product/production life cycle. During the phase of detailed engineering, for instance, an industrial project could concentrate on balancing a new production line. Divided into subtasks and assigned to student teams. The students work to solve these problems by communicating with engineers and creating and evaluating their ideas and solutions utilizing modern computer science technology. The project is backed by an educational strategy that combines logistics and specifics into academic practice, as well as a computer science technology strategy that facilitates contacts between factories and classrooms. A weekly cycle of sessions consisting of support classes, project work, and direct factory involvement is used to manage industrial projects. Every work session involves direct communication with the plant. Depending on the nature of the topic, these interactions may involve conversations, sharing of presentations, live videos of production, and other information distribution channels. Students must do project work between hands-on sessions, which may involve experimentation or data analysis to generate fresh insights and solutions. The academic supervisor moderates the support class and is also responsible for stimulating discussion and providing advice in identifying solutions.

Implementing the Teaching Factory must be based on the results of discussions between schools and teaching teachers by looking at the needs of students in achieving competence and seeing the needs of the business/industry world. In the case study of Sri's research, schools must provide several supports, including Technology Support. Schools, by providing facilities with the latest technology, are evidenced by the availability of production equipment which includes all required production; Curriculum support, especially the curriculum in the application of the Teaching Factory concept, a particular strategy to combine the rules in the national curriculum with the application of the teaching factory concept is needed.

Learning activities apply understanding and skills in producing products through the practical school of change management to industrial management, the experimental stage of communication by considering theoretical contact, and the experimental stage of sequence analysis. Phase 1 changed school management to industrial management, not by involving students but by teachers and schools. Stage 2, the practice of communication by considering communication theory, is not carried out in the implementation of factory teaching. Similar activities were also carried out in teacher briefing on the overall teaching of factory implementation. Stage 3, analysis of practice orders, was carried out in the implementation teaching factory.

Its main activities are divided into the introductory stage and the main stage. The introductory stage consists of three steps, namely (Step 1) receiving the order, (Step 2) analyzing the order, and (Step 3) stating readiness to place an order. The main stage consists of three steps, namely (Step 4) placing the order, (Step 5) carrying out quality control, and (Step 6) giving the order to the ordering provider. Steps 1 and 2 are combined and carried out under production preparation. Step 3, stating the readiness to carry out the demand, was not carried out in the school factory teaching as the production implementation was not order-oriented. Step 3, the practice of sequence analysis, is modified by the practice of analysis of production activities. Step 4 is to place an order or production activity. Step 5 is being carried out with quality control. Activities carried out by students are matching product numbers, products, and physical security products. However, in terms of physico-chemical and microbiological quality, quality control activities were not carried out. The Closing / Evaluation stage is carried out at the factory teaching implementation. The activities carried out by the teacher evaluate the results, processes, and learning programs.

2. Obstacles To Implementing A Teaching Factory In Indonesia

The obstacle that occurs in teaching factories in Indonesia is the limited resources owned by the school, especially capital and experts. In optimally implementing it, capital is needed to prepare adequate infrastructure and networks for implementing an optimal teaching factory. Likewise, with the availability of experts who can provide the latest knowledge following the industrial era 4.0 in Indonesia.

According to Mourtzis, combining traditional methods and Industry 4.0 technology will create results that will be of great interest to aspiring professionals, helping to smooth their integration into manufacturing. The Teaching Factory paradigm involves involvement and collaboration between prospective engineers/professionals and experts in their fields where there is a transfer of knowledge and experience. In addition, it is crucial to improve the conventional training of manufacturers and increase their contribution to new digital technologies. The transition from traditional course instruction to the Education 4.0 framework necessitates careful planning and the incorporation of traditional production techniques and the technology provided by Industry 4.0.

Using activity simulations, students validate a new concept for a manufacturing facility. During the courses, production engineers and simulation experts interact with students. Students can establish workload methods for each system's processing time sensitivity through testing. In addition, students must design material flows in accordance with people and equipment resources for industrial challenges. They provide an understanding of the appropriate positioning of various components based on product variability, as well as the location of material feeding equipment and personnel. The students managed to identify the bottleneck that disrupted the assembly line from the production area.

According to Mourtzis, Future work is modular, so that Teaching Factory might be a perfect fit within the needs of the limitations of academia and industry. Not all manufacturing problems can be solved through the method chosen for the pilot case of this study. With computer information technology, it can help concepts to be easily implemented. Teaching Factory's computer information technology should be improved in terms of its practical content. There may be several "Factory" and "classroom" locations in the future. Teaching Factory may also have a substantial effect on vocational education. New technology and manufacturing concepts can be communicated to industrial environment operators. In addition, utilizing the Teaching Factory model can promote entrepreneurship in universities and innovation within businesses through collaborative projects involving academia and industry.

E. CONCLUSION

The implementation of the teaching factory is still not running correctly because there is no common understanding regarding the teaching factory learning pattern with related parties such as educators, education staff, students, parents/guardians of students, and school partners so that an understanding and effective cooperation have not been reached. However, there are often obstacles regarding this in implementing these activities. In addition, due to limited resources (capital and experts), not all schools can carry out this teaching factory optimally, but they try to continuously improve the quality of the teaching factory gradually and constantly until it reaches the expected point.

There are several things that can be recommended, namely during the preparation of the study: It is necessary to consider the appropriate scheduling and arrangement of lesson plans for the Teaching Factory; At the time of facility preparation, it is essential to keep track of the completeness of industry standard tools and periodic Maintenance, Repair and Calibration management tools; In the preparation of human resources, it is crucial to consider the competence of teachers implemented by Teaching Factory; Regarding implementation, it is necessary to consider Teaching Factory based on corporate culture; In relation to the products produced by the Teaching Factory, it is required to pay attention to the conformity of quality with standards and quality control on a regular basis; Optimizing the relationship with industry is very important to assist the learning process of science and technology transfer, investment by industry, and project work activities; The continuous evaluation of the implementation of Teaching Factory by schools is very large to ensure the passage of the entire Teaching Factory process, monitoring the potential, obstacles, and basic needs for the implementation of factory teaching in the future.

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