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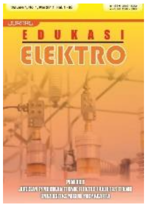

Development of Teaching Factory Learning Model in Industrial Automation in Vocational High Schools

Yuwono Indro Hatmojo[1] (✉), Wahyu Ikhsannudin Ikhsannudin[1]

[1] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

yuwono_indro76@uny.ac.id

Abstract— Vocational High Schools, as schools that aim to prepare students for work in a particular field, need effectiveness in the learning process. Its effectiveness must follow the real conditions required by the industry. With the rapid development of industry, industry-based learning, often called "Teaching Factory," is one of the right role models of learning. The type of research to be carried out is development research. The purpose of this study is to determine (1) the development of the teaching factory learning model, (2) the application of the teaching factory learning model, (3) user response to the product, and (4) the effectiveness of using the developed product. The development model used in this study is the Plomp development model. The Plomp development model includes (1) the initial investigation phase, (2) the design phase, (3) the realization/construction phase, (4) the testing, evaluation, and revision phase, and (5) the field test/implementation phase. Validity by model experts about the teaching factory learning model gets an average score of 95.45 and is included in the very decent category. The material expert gave it a score of 93.41, and it belongs to the very decent category. The media expert gave it a score of 95.84, which belongs to the decent category. The effectiveness test result shows a significant difference between the learning outcomes in the Industrial Automation Engineering Expertise Concentration subjects before and after applying the Teaching Factory learning model. This shows the positive influence and effectiveness of using the Teaching Factory learning model on the learning outcomes of the Industrial Automation Engineering Expertise Concentration in Industrial Automation Engineering Vocational School students.

Keywords: learning model, teaching factory, industrial automation engineering.

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1 Introduction

Improving the quality of Human Resources (HR) in Indonesia can be achieved by implementing continuous formal and informal education processes. Vocational High Schools (VHS) are one of the formal education institutions for HR development. The government aims to accelerate and expand the creation of competent and competitive Indonesian HR to face global challenges [1]. This is intended to ensure that graduates of vocational education and training, both formal and non-formal, are capable of being valuable assets to the business and industrial sectors, no longer contributing significantly to unemployment rates.

As of February 2022, the unemployment rate for VHS graduates was recorded at 10.38% [2], which is the highest among graduates of different educational levels. This research finding contradicts the goal of vocational education, which aims to shape and prepare students to have skills aligned with their interests and talents for the workforce.

The distribution and growth of the Gross Domestic Product (GDP) by the largest sectors, according to the leading sectors, place the industrial sector at the top with a distribution percentage of 17.88%, higher than mining, agriculture, and others [2]. This report indicates that assessing Indonesia's economic condition can be done by examining the distribution of the total value of final goods and services produced by the industrial sector, given its high percentage. Hence, the need for competent HR in the industrial sector is crucial for economic growth in Indonesia.

With increasing trust from the business sector in VHS, the learning process in VHS needs to be enhanced. VHS, as a formal education institution that provides vocational education, involves both theoretical and practical learning. VHS students spend more time on practical training (60%) compared to theoretical classes (40%) [3]. With this percentage, students spend more time in practical workshops than in classrooms. The theoretical and practical learning process forms an inseparable unit in the teaching and learning activities at school.

Industrial Automation Engineering is a specialization in VHS where theoretical learning cannot be separated from practical training. Based on the Merdeka Curriculum Spectrum, the allocation of the number of lesson hours for vocational subjects shows that 65% of the total lesson hours per year in grade 10 are dedicated to vocational learning, 74% in grade 11, and 91% in grade 12. Based on these percentages, it is evident that the higher the level of education a student achieves in VHS, the more vocational subjects they will study.

There is a mismatch between the qualifications of higher education and vocational education graduates and the qualifications expected by the industry. This mismatch trend will persist if there is no effective bridge between the education sector and the industry [4]. Mismatched qualifications may occur due to discrepancies between what is taught in VHS and the actual field application. Enhancing skill proficiency systematically and purposefully through hands-on application, not just theoretical knowledge, can be combined with the needs of the existing industry.

According to the Ministry of Education and Culture [5], the application of 21st-century skills expects students to possess the 6Cs: character, citizenship, creativity, critical thinking, communication, and collaboration. With these skills, it is expected that Indonesian students can adapt to technological advancements and compete globally. Learning in VHS can integrate 21st-century skills with the ideal HR needs for the industry [6].

Educators can implement 21st-century skills by shifting from traditional teaching methods to student-centered approaches [7]. Educators can apply these skills to students to prepare them for the challenges of the 21st century. One challenge for students is meeting the qualifications required by the industry. Educators can introduce students to industry qualifications as early as possible by implementing authentic learning experiences that align with industry conditions in the VHS learning process [8].

The Teaching Factory is a production facility operated based on actual work procedures and standards to produce products by real industry conditions and is not profit-oriented [9][10]. By following real industry conditions in the learning process at VHS, collaboration with partner industries will be encouraged. As a result, VHS will naturally keep pace with industry developments [11].

Based on a pre-survey conducted in December 2022, it was found that the Teaching Factory has not yet been implemented at VHS Negeri 1 Japara as part of the learning process. This is due to the lack of synchronization between vocational subject materials and the products to be produced in the production unit, as well as with partner industries. Additionally, HR is not yet proficient in using various teaching methods and models, and there are no established procedures or workflows for implementing the Teaching Factory model. In the practical training process, especially in the Industrial Automation Engineering department, practical learning is still suboptimal due to the predominantly classical teaching methods, which do not incorporate the latest teaching models in line with 21st-century learning and industry needs.

Relevant research was conducted by Wahyuni [12] on the "Application of the Teaching Factory Learning Model in Improving Learning Activities and Learning Outcomes of Students in the Food Processing and Presentation Subject." This research aimed to evaluate whether the application of the Teaching Factory learning model in the subject of food processing and presentation could enhance the learning activities and learning outcomes of 11^{th}-grade Culinary 2 students at VHS Pratama Widya Mandala Badung. The conclusion was that the application of the Teaching Factory learning model effectively improved the learning activities and learning outcomes of the students. This study shares similarities with previous research on the Teaching Factory learning model, but there are differences in the research context. Previous research focused on the application of the Teaching Factory learning model in the culinary field, while the upcoming research will focus on the field of industrial automation. Additionally, the research locations differ, with the previous research conducted at VHS Pratama Widya Mandala Badung, while the upcoming research will involve VHS Negeri 1 Japara and VHS Negeri 3 Kuningan.

Furthermore, another relevant study by Kurniawati [13] concerns the "Implementation of Project-Based Teaching Factory Learning in the Motorcycle Workshop of VHS Raden Rahmat Mojokerto." This research aimed to analyze the implementation of Teaching Factory learning, including supportive policies, planning, implementation, evaluation, challenges, and efforts in implementation, as well as the sustainability of the Teaching Factory. The research findings indicated that school policies support the implementation of Teaching Factory learning. In terms of planning, curriculum synchronization is required annually to keep up with technological developments in the industry. However, there are differences as well. In the above-mentioned research, the focus was on analyzing the implementation of Teaching Factory learning, while the upcoming research will aim to develop a Teaching Factory learning model. Additionally, there is a difference in the type of product innovation being developed, as the above-mentioned research focused on product innovation in the field of motorcycle engineering, whereas the upcoming research will focus on product innovation in the field of industrial automation. Another difference lies in the study subjects, as the researcher mentioned above used students from VHS Raden Rahmat Mojokerto, while the upcoming research will be conducted at VHS Negeri 1 Japara and VHS Negeri 3 Kuningan.

2 Method

This research employs the Research and Development (R&D) method, where R&D aims to produce a specific product and test its effectiveness [14]. In this study, the Plomp development model [15] is utilized. The Plomp development model characterizes educational field design as a method that can be systematically used to address encountered problems. This research consists of three phases: the preliminary research phase, the prototyping phase, and the assessment phase. In the preliminary research phase, a preliminary study is conducted to obtain the necessary information and data for product development. The development phase aims to design and create the desired product, while the assessment phase is carried out to evaluate the effectiveness of the product. The choice of using the Plomp model for development is due to its relative simplicity and practicality as a developmental model that is associated with field implementation at each stage.

The design of the trial is carried out with the aim of conducting experiments to understand the responses/feedback from potential users within the school, namely teachers and students, regarding the final product. The trial was conducted at VHS Negeri 1 Japara, located at Jl. Raya Puskesmas, Kec. Japara, Kab. Kuningan, West Java, and VHS Negeri 3 Kuningan, located at Jl. Raya Cirendang, Cirendang, Kec. Cigugur, Kabupaten Kuningan, West Java.

The trial subjects for the Teaching Factory learning model product are students of the 11th grade specializing in Industrial Automation Engineering at VHS Negeri 1 Japara and VHS Negeri 3 Kuningan, as well as educators specializing in Industrial Automation Engineering. The selection of trial subjects was made with the consideration that these schools are VHS institutions offering a specialization in Industrial Automation Engineering in Kuningan Regency and are part of schools that have received the Center of Excellence for VHS program. Given their designation as a Center of Excellence school, it is expected that the schools share a common understanding of the concept of industry-based learning or the well-known Teaching Factory approach.

To ensure the validity of the information obtained, researchers must use appropriate and structured data collection techniques in their research process. In this R&D study, the developer gathered data through observation and research instruments. Observation serves not only to measure respondents' attitudes but also to record various phenomena. Observation data is used for the trial phase, involving user responses to the model. The data collection techniques used at each stage of the research are as follows.

a. Data collection techniques include observation and interviews in the initial investigation phase.
b. Observation data collection techniques are employed in the design phase, and observation data collection is also carried out during the development phase, including validation by subject matter experts, media experts, and educational experts.

3 Result and Discussion

The form of developing the Teaching Factory learning model in industrial automation engineering that is produced is a structured learning model from the beginning to the end of the learning process. It serves as a practical learning guide for teachers to facilitate industrial automation engineering students in vocational schools, emphasizing the active role of learners in building knowledge and skills through direct experience in line with the realities of the working world. The development process of the Teaching Factory learning model is carried out in three stages, namely the preliminary research phase, prototyping phase, and assessment phase.

In the preliminary research phase, several observations were conducted, including front-end analysis, student analysis, content analysis, and competence analysis. Front-end analysis aims to analyze the main problems faced in the learning process to enhance the quality of practical learning. In this analysis, classroom observations and interviews were conducted with educators specializing in Industrial Automation Engineering. During the observation, it was found that the Teaching Factory had not been implemented in the learning process. This was primarily due to the lack of synchronization between the curriculum content and the products to be produced in the production unit, as well as the unpreparedness of the teaching staff to employ various teaching methods and models, along with the absence of procedures or guidelines for implementing the Teaching Factory learning model. In the analysis of students, the characteristics of the students during the learning process were evaluated. Based on interviews with the Industrial Automation Engineering educators at VHS Negeri 1 Japara, it was reported that student learning outcomes were not optimal. This was evident from the students' grades, as 45% of the students in one class did not achieve a score of 75. According to the educators, this was attributed to a decreasing enthusiasm among students to study electromechanical control system materials. Content analysis involved determining the curriculum materials based on the learning outcomes in Industrial Automation Engineering and the Indonesian National Qualifications Framework (KKNI). This analysis was conducted through collaboration between the educators of Industrial Automation Engineering and PT. Bisnis Digital Ekonomi, which represented the industry partners of VHS Negeri 1 Japara. This curriculum synchronization resulted in several projects that could be applied in the learning process. Here is a table of the results of the alignment of Learning Outcomes for Phase F in Industrial Automation Engineering on the Merdeka Curriculum with the Level II Units of the Indonesian National Qualifications Framework (KKNI) in Industrial Automation Engineering (TOI).

Tabel 1. The synchronization of the curriculum between learning outcomes and KKNI.

TOI Learning Outcomes	KKNI Level II TOI Units	Analysis of Synchronization Results	Project Development
Electromechanical Control Systems Electronic Control Systems	Operating Electrical Systems	Electromechanical Control Systems	Automatic Door Opener
	Operating Electronic Equipment	Automated Control Systems	Automated Greenhouse
	Operating Electronic Systems		
Industrial Sensor and Actuator Devices	-		
Control System, Electropneumatic and Hydraulic Control Systems	Operating Pneumatic Equipment	Electropneumatic and Hydraulic Control Systems	Conveyor Belt Control
	Operating Hydraulic Equipment		
	Operating Pneumatic Systems		
	Operating Hydraulic Systems		
Industrial Control Systems	Operating Programmable Logic Controllers (PLC)	Programmable Control Systems	Smart Parking System
Industrial Robot Systems	Operating Operating Robot Systems (Handling System)		
	Operating Supervisory Control and Data Acquisition (SCADA) Systems		

The final analysis conducted was competence analysis. This involved evaluating the 21st-century skills that students in Industrial Automation Engineering must possess to meet industry needs. Furthermore, the direction of developing the learning model and its principles and learning procedures is based on the established Teaching Factory learning model theories. The procedural stages in implementing the Teaching Factory learning model include (1) order acceptance, (2) observation, (3) product design, (4) product testing, (5) product delivery, and (6) sustainability improvement. The learning process in the Teaching Factory model is supported by teaching materials consisting of teaching modules and Learner's Worksheets or job sheets. In this learning process, the Teaching Factory model also encourages participants to master 21st-century skills, including critical thinking, collaboration, communication, creativity, citizenship, and character [16]. The outcome of the Teaching Factory learning model is graduates who have competence in the field of industrial automation and strong 21st-century skills, making them ready to face the continually evolving and competitive job market.

In the prototyping phase of the Teaching Factory learning model, the process begins with an initial design, which includes designing a user guide for implementing the Teaching Factory learning model and its teaching materials. In this stage, the model developer creates learning components based on initial observations and follows the rules of the Teaching Factory learning model. This design is then evaluated and adjusted according to the school and industry's needs. Subsequently, teaching materials such as teaching modules and student worksheets are developed. The teaching module contains information about the objectives, teaching materials, teaching methods, and assessment of learning outcomes, while the student worksheet is used as a guide for students during the learning process. The next stage involves the realization of the designed components, including the arrangement of teaching syntax, implementation strategies, and the conditioning of the Teaching Factory. The result of the prototyping phase is a set of teaching materials that align with the Teaching Factory learning model for the Industrial Automation Engineering concentration in Vocational High Schools (VHS).

Fig. 1. Prototype 1 consists of a manual for implementing the teaching factory learning model, teaching materials, and research questionnaire instruments.

In the assessment phase, the steps include validation, revision, and testing. In the validation stage, the instruments created in the previous phase have been validated by instrument validators, and the response questionnaires and surveys are ready for use. In addition to the instruments that are ready for use, the manual for implementing the teaching factory learning model and the teaching materials are prepared for validation in a focus group discussion (FGD) session. During the discussion process, the manual for implementing the teaching factory learning model and the teaching materials are revised and ready to be tested in the learning process at school.

The next step following the implementation of the Teaching Factory learning model module and teaching materials is to conduct an internal conceptual validation of the initial prototype. In this validation process, the initial prototype is presented to a group of validators, including model experts, subject matter experts, and media experts. The purpose of this validation is to gather input, feedback, and assessments from these experts to ensure that the prototype meets the required conceptual standards for the Teaching Factory learning model. Therefore, the results of this validation will help refine the prototype and ensure its quality and effectiveness in implementation.

Validation by model experts is a crucial stage in the development of the Teaching Factory learning model. Model experts possess in-depth knowledge of the principles and framework that underlie this learning approach. The following are the results of the model validation by model experts.

Tabel 2. Model validation by model experts for the learning model guidebook and teaching materials

Aspect	Indicator	Average (%)	Category
Input	Enthusiasm	91.6	Very Feasible
	Discipline	100	Very Feasible
	Availability of Facilities and Infrastructure	91.6	Very Feasible
	Readiness of Educators	91.6	Very Feasible
	Environment	95.8	Very Feasible
Process	Engagement	91.6	Very Feasible
	Exploration	95.8	Very Feasible
	Explanation	91.6	Very Feasible
	Elaboration	100	Very Feasible
	Evaluation	100	Very Feasible
Output	Utilization of the Learning Model	100	Very Feasible
	Listing Data/Information Sources	95.8	Very Feasible

Validation of the material by subject matter experts is a crucial step in ensuring the quality and accuracy of the content of the Teaching Factory learning model. The results of this validation allow for verification that the content presented aligns with curriculum standards and current industry practices. Here are the results obtained from the material validation.

Tabel 3. Material validation by subject matter experts on the instructional guide for the learning model and teaching materials

Aspect	Indicator	Average (%)	Category
Content Suitability	The description of these terms and ideas, as presented in the book, should be contextual and in line with the applicable curriculum.	94.4	Very Feasible
	The content within the book should be trustworthy, accurate, and should refer to credible source material, both theoretically and empirically.	97.2	Very Feasible
	The emphasis should be on maintaining a balance between the depth and breadth of the content, suitable for the developmental level of the readers.	97.2	Very Feasible
	Information within the book should be presented clearly, concisely, and without bias.	91.6	Very Feasible
	It should include diverse descriptions that encourage and motivate learners to develop themselves.	94.4	Very Feasible
	The book should contain a variety of sample questions and exercises with different formats and levels of difficulty, which are contextual for each topic, considering the current and future needs of the learners.	94.4	Very Feasible
Support for Learning Suitability	It should present various activities with a logical sequence that is easy for learners to understand, inspiring and encouraging active participation.	94.4	Very Feasible
	The material should be accompanied by contextual case examples that support 21st-century learning	94.4	Very Feasible
21st Century Skills	Character	94.4	Very Feasible
	Citizenship	88.8	Very Feasible
	Critical thinking	94.4	Very Feasible
	Creativity	91.8	Very Feasible
	Collaboration	88.8	Very Feasible
	Communication	91.6	Very Feasible

Media validation is an important step in ensuring that the Teaching Factory learning model can be presented effectively and engagingly to students. The results of media validation help ensure that the use of media, whether in the form of instructional guides for the Teaching Factory learning model or its learning materials, can enhance students' absorption and understanding. Here are the results obtained from media validation.

Tabel 4. Media validation by media experts on the instructional guide for the learning model and teaching materials

Aspect	Indicator	Average (%)	Category
Language Feasibility	Using effective, clear, communicative, and informative sentences that are interconnected and suitable for the students' developmental level.	100	Very Feasible
	Incorporating words and/or terms that are appropriate, in line with the discipline of knowledge, and suitable for the students' developmental level.	97.9	Very Feasible
	Providing descriptions that adhere to applicable regulations and norms while avoiding elements of SARA (ethnic, religious, racial, and societal discrimination).	100	Very Feasible
	Utilizing proper and correct Indonesian language following the rules and guidelines set by the language institution.	97.9	Very Feasible
Presentation Feasibility	Presenting the material in an engaging and coherent manner to maintain its meaning effectively.	89.6	Very Feasible
	Depicting images and graphical illustrations in an appealing and accurate manner to clarify the content while being appropriate for the students' developmental stage.	95.9	Very Feasible
	Excluding sentences, images, and other illustrations containing elements of pornography, extremism, radicalism, violence, SARA, gender bias, or other deviations.	97.9	Very Feasible
	Using high-quality paper and ensuring good printing and binding quality in the physical production of the material.	87.5	Very Feasible

The data in Table 2 reveals that in the model validation process, the average score achieved is outstanding at 95.48%. This process can be considered very suitable, indicating that the Teaching Factory learning model has undergone careful evaluation and has met high-quality standards successfully. Furthermore, when we look at Table 3, we find that the validation of materials also impresses, with an average of 93.45%. This is a strong indication that the content of the materials has been meticulously prepared and is suitable for learning needs. Similarly, in media validation, the average reaches 95.83%, demonstrating that the use of media in this learning model is highly effective and supportive of the learning process. Overall, these results reinforce the impression that the Teaching Factory learning model has undergone a highly satisfactory validation process, ensuring the quality and effectiveness of content delivery to learners.

4 Discussion

The learning model, as explained by Eggen & Kauchack [17], provides a framework and direction for teachers in their teaching. Suprijono [18] adds that the learning model is a conceptual framework that organizes learning experiences to achieve specific goals. In the context of the Teaching Factory learning, this model plays a central role in guiding educators and students to achieve learning objectives focused on the automation industry. With clear principles and an organized structure, the Teaching Factory learning model enables students to actively engage in learning experiences that reflect the industrial world.

Constructivism theory plays a significant role in the Teaching Factory learning approach [19]. Constructivism emphasizes the active role of students in constructing knowledge through direct experiences [20]. The theories of Piaget, Vygotsky, and Dewey provide a foundation for the constructivist approach to learning. By integrating constructivist theory, students in the Teaching Factory could develop their understanding and skills through active interaction with the production process, creating deep and meaningful learning experiences.

The development of the Teaching Factory model involves a series of structured steps. The initial preparation phase requires commitment and collaboration between schools and the industrial world. By integrating various aspects that align with industry standards and product innovation, the Teaching Factory can produce competent graduates in line with market demands [21]. These steps provide a strong foundation for preparing students to face the challenges of the working world.

The Teaching Factory learning process involves six stages designed to provide a comprehensive learning experience. The order acceptance stage teaches students to understand customer needs and develop appropriate action plans. In the observation stage, students learn to gather relevant industrial data and analyze it carefully. The product design step teaches students the importance of thorough and detail-oriented design. Product testing allows students to test and improve their products before marketing them. The order delivery stage teaches students about efficient delivery management and precision in packaging products. Finally, the sustainability improvement stage teaches students to continually improve the quality and positive impact of their products or services, ensuring long-term operational sustainability.

Overall, the Teaching Factory learning model combines constructivism theory with a practical approach to prepare students for the world of the automation industry. By using a structured and focused learning model, the Teaching Factory provides deep and relevant learning experiences for students, enabling them to develop skills and knowledge that align with industry needs. By considering the principles and stages in the development of the Teaching Factory learning model, educators can guide students toward success in the working world with better readiness.

5 Conclusions

This research confirms that the curriculum in Vocational High Schools must be in line with industry. Alignment in terms of learning outcomes and competencies is carried out with discussions between Vocational High Schools and industry. These same competencies are then implemented in real learning in vocational educators and are called teaching factory model learning. The use of the teaching factory learning model is proven to be able to solve the differences in competencies produced by Vocational High Schools and competencies needed by industry. The same educational atmosphere as the working atmosphere in the industry is one part of the teaching factory learning model.

6 References

[1] Pemerintah Indonesia, "Peraturan Presiden Republik Indonesia Nomor 62 Tahun 2022 tentang Revitalisasi Pendidikan Vokasi dan Pelatihan Vokasi," *Kementeri. Sekr. Negara Republik Indones.*, no. 132424, pp. 1–19, 2022, [Online]. Available: https://peraturan.bpk.go.id/Home/Details/207855/perpres-no-68-tahun-2022.

[2] B. P. Statistik, "Keadaan Ketenagakerjaan Indonesia Agustus 2019," *Badan Pus. Stat.*, vol. 11, no. 84, pp. 1–28, 2021.

[3] D. Diksi, "Ini Alasan Kamu Sebaiknya Masuk SMK!," *Dirjen Vokasi*, 2022. https://www.vokasi.kemdikbud.go.id/read/b/ini-alasan-kamu-sebaiknya-masuk-smk (accessed Nov. 02, 2023).

[4] D. Nurhidayat, "Pengamat: Kualifikasi Sarjana dan Lulusan SMK Tidak Sesuai dengan Kebutuhan Industri Sumber: https://mediaindonesia.com/humaniora/563152/pengamat-kualifikasi-sarjana-dan-lulusan-smk-tidak-sesuai-dengan-kebutuhan-industri," *www.mediaindonesia.com*, 2023. https://mediaindonesia.com/humaniora/563152/pengamat-kualifikasi-sarjana-dan-lulusan-smk-tidak-sesuai-dengan-kebutuhan-industri (accessed Nov. 02, 2023).

[5] Kemdikbud, "Mengenal Peran 6C dalam Pembelajaran Abad ke-21," *Kemdikbud*, 2022. https://www.kemdikbud.go.id/main/blog/2022/09/mengenal-peran-6c-dalam-pembelajaran-abad-ke21 (accessed Nov. 02, 2023).

[6] S. K. Le, S. N. Hlaing, and K. Z. Ya, "21st-century competences and learning that Technical and vocational training," *J. Eng. Res. Lect.*, vol. 1, no. 1, pp. 1–6, Nov. 2022, doi: 10.58712/jerel.v1i1.4.

[7] N. Aida, "Mewujudkan Keterampilan 4C Abad 21," *https://kalsel.kemenag.go.id*, 2020. .

[8] H. Mustafa, M. A. Mohammad Hussain, and R. M. Zulkifli, "Industries and Vocational Training Centres Partnership: Issues and Improvement Plan," *Int. J. Acad. Res. Progress. Educ. Dev.*, vol. 11, no. 1, pp. 134–144, 2022, doi: 10.6007/ijarped/v11-i1/11959.

[9] Peraturan Pemerintah, "Pembangunan Sumber Daya Industri," 2015.

[10] I. N. Saputro, "Literature Review of The Development of a Green Campus Teaching Factory-Based Learning Model in Vocational Schools in Indonesia," ... *J. Pendidikan, Sos. dan Agama*, vol. 16, no. 1, pp. 65–76, 2024, doi: 10.37680/qalamuna.v16i1.3438.

[11] J. Strobel, J. Wang, N. R. Weber, and M. Dyehouse, "The role of authenticity in design-based learning environments: The case of engineering education," *Comput. Educ.*, vol. 64, pp. 143–152, May 2013, doi: 10.1016/j.compedu.2012.11.026.

[12] N. K. A. Wahyuni, N. M. E. O. Astuti, and I. W. Suryanto, "Penerapan Model Pembelajaran Teaching Factory untuj Meningkatkan Aktivitas Belajar dan Hasil Belajar Siswa pada Mata Pelajaran Pengolahan dan Penyajian Makanan," *MEDIA EDUKASI J. ILMU Pendidik.*, vol. 4, no. 2, 2021.

[13] W. Kurniawati, "Implementasi Pembelajaran Teaching Factory Berbasis Proyek di Bengkel Sepeda Motor SMK Raden Rahmat Mojokerto," 2023.

[14] Sugiyono, *Metode Penelitian kuantitatif, kualitatif dan R & D / Sugiyono*. Bandung: Alfabeta, Bandung, 2014.

[15] T. Plomp and N. M. Nieveen, *An introduction to educational design research*. Enschede, The Netherlands: SLO, 2010.

[16] J. Uzoamaka, Anekwe, “Teaching and Learning of 21st Century Learners in Anambra State Secondary Schools: Exploring teacher’s preparation and learning environment,” Oct. 2020, doi: 10.33422/2nd.ntteconf.2020.10.51.
[17] P. Eggen and D. Kauchak, “Strategies and Models for Teachers,” *Pearson*, vol. 72, no. 508, p. 343, 2012, [Online]. Available: https://www.pearsonhighered.com/assets/preface/0/1/3/2/0132179334.pdf.
[18] A. SUPRIJONO, *Cooperative Learning (Teori dan APlikasi PAIKEM)*. Yogyakarta: Pustaka Pelajar, 2009.
[19] P. T. Kieu Oanh and N. T. Hong Nhung, “Constructivism learning theory: A Paradigm for Teaching and Learning English in secondary education in Vietnam,” *Int. J. Sci. Res. Publ.*, vol. 12, no. 12, pp. 93–98, 2022, doi: 10.29322/ijsrp.12.12.2022.p13211.
[20] S. Suparlan, “Teori Konstruktivisme dalam Pembelajaran,” *Islamika*, vol. 1, no. 2, pp. 79–88, 2019, doi: 10.36088/islamika.v1i2.208.
[21] Direktorat PSMK, “Panduan Pelaksanaan Teaching factory,” *Pros. Semin. Nas. Pendidik. Tek. Otomotif UMP 23 Mei 2015 Teach.*, vol. 3, no. 20, p. ISSN: 2338-0284, 2019, [Online]. Available: http://staff.uny.ac.id/sites/default/files/penelitian/ibnu-siswanto-mpd/teaching-factory-bidang-keahlian-otomotif.pdf.

7 Authors

Yuwono Indro Hatmojo is a lecturer in the Electrical Engineering Education Department, Faculty of Engineering, Universitas Negeri Yogyakarta (email: yuwono_indro76@uny.ac.id).

Wahyu Ikhsannudin is a student in the Master program at the Department of Electrical Engineering Education, Faculty of Engineering, Yogyakarta State University (email: wahyuikhsannudin.2022@student.uny.ac.id).