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Industrial Apprenticeship Model Based on Work-Based Learning for Pre-service Teachers in Automotive Engineering

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The low vocational competence of vocational teachers has become an essential issue in the last few decades. This problem is due to the lack of actual work experience in the industry for vocational teachers. One of the vocational skills improvement programs that are considered adequate is the industrial apprenticeship program. Many studies discuss apprenticeships, but there are still limited studies that examine effective apprenticeship programs to improve the competence of pre-service teachers at automotive engineering Vocational High Schools. Therefore, this study aims to determine the development of a Work-Based Learning (WBL)-based industrial apprenticeship model and its effectiveness to improve the competence of pre-service teachers at Vocational High Schools in the field of automotive engineering. This study uses an Education Research and Development (R&D) approach and involves two campuses in Central Java-Indonesia. There were 20 pre-service vocational teachers and three industry parties involved in the preliminary study. The preliminary study aims to obtain information about the problems and needs of the apprenticeship model. Furthermore, there were 60 pre-service vocational teachers and 12 industry parties involved in a follow-up study to test the effectiveness of the apprenticeship model. The sampling technique used is purposive sampling. The study results revealed that the WBL-based industrial apprenticeship model for pre-service vocational teachers in the automotive engineering field was considered feasible. In addition, the implementation of a WBL-based industrial apprenticeship can improve the competence of pre-service automotive engineering teachers, which includes knowledge, attitudes, and skills in the field of automotive engineering. The results of this study have implications for vocational education practitioners, especially higher education that organizes teacher education programs, to apply this apprenticeship model in preparing pre-service vocational teachers. This is because the WBL-based industrial apprenticeship model for pre-service vocational teachers plays a vital role in improving vocational skills for pre-service vocational teachers.

Keywords: teacher apprenticeships, pre-service teacher, vocational schools, Work-Based Learning, automotive engineering

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INTRODUCTION

In general, teachers have an essential role in providing quality education. Many studies highlight that teacher quality is a determinant of the effectiveness of instruction in schools, ultimately affecting student achievement (Bourgonje and Tromp, 2011; Bakar, 2018; Mahfud et al., 2019a; Suyitno et al., 2019; Kholifah et al., 2020; Madigan and Kim, 2021; Wedel, 2021). In vocational education, teachers play a role in preparing skilled workers according to their fields of expertise. Vocational teachers have dual roles as teachers and as professional instructors for vocational students. So that the preparation of qualified vocational teachers is an important aspect that needs to be developed. Therefore, over the last few decades, the Indonesian government has been pressing to improve the quality of vocational teachers by producing and expanding vocational teacher policies. For example, the Government of Indonesia has highlighted the importance of preparing vocational teachers by accelerating the provision of vocational teachers for Vocational High Schools through education, equalization, and recognition (President of the Republic of Indonesia, 2016). The strategy of preparing quality teachers can encourage a decrease in the unemployment rate for vocational high school graduates, which still dominates as the open unemployment rate based on education in Indonesia.

Judging from the level of education, Vocational High Schools contribute 8.63 per cent to the unemployment rate, and this value is the highest among other education levels (Badan Pusat Statistik, 2019). The unemployment data for Vocational High School graduates illustrates that Vocational High School students each need quality teaching from their teachers (Hanapi and Nordin, 2014). Quality teaching is obtained from quality teachers. In addition, in the twenty-first century, there has been a significant transformation in social, economic, political, and cultural aspects (Hargreaves, 1997) driven by four major interrelated forces, namely advances in science and technology, demographic change, globalization and the environment. This situation has encouraged vocational teachers to have increased professional qualifications as vocational education teachers following the needs of the world of work (Partnership for 21st Century Skills, 2010). Therefore, teacher education plays a vital role in preparing qualified vocational teachers, especially for vocational teachers in automotive engineering.

Furthermore, future vocational teacher education in automotive engineering faces serious challenges. The emergence of various car models, recent advances in-car technology, environmental pollution problems, and critical issues related to sustainability. This diversity of car models and technology increases the complexity of the model for preparing pre-service vocational teachers because teachers are required to master new technologies in the automotive sector. There has been much criticism of the ineffectiveness of preparing vocational teachers to do their job (McEntire and Hukill, 1977; Lilly and Efajemue, 2011; Kennedy et al., 2017). For example, overcrowded classes for teacher trainees, inequality in teacher placement in urban/rural areas, poor funding and inadequate facilities, low-quality Information and Communications technology (ICT), compliance and non-professionalization of teaching, and lack of technical training about the teacher's vocational field (Kennedy et al., 2017). The problem of the low vocational skills of vocational teachers is often the root of the problems of vocational education.

Reform efforts in vocational teacher education that include structural and conceptual changes are currently underway. One of the criticisms related to the quality of teachers is the lack of vocational skills in teaching, thus causing the low vocational skills of students. Whereas, according to Prosser and Quigley that vocational education will be proportionally effective if the teacher or instructor has had successful experience in applying skills and knowledge to operations and work processes to be carried out (Prosser and Quigley, 1949). Thus, mastery of pedagogical and technical skills is essential for vocational teachers. The basic principle of implementing vocational education involves the industry in formulating curricula, implementing learning, testing professions, and distributing graduates (Soenarto, 2003). Prosser and Quigley (1949) also highlighted the importance of developing vocational education based on workplace needs and situations. The 16 principles of Prosser and Quigley highlight the need to adapt the learning situation at school to the workplace. Adjustments between educational institutions and industry include the suitability of teacher qualifications, industrial-like learning places, and industry-standard-based learning facilities. To adjust teacher qualifications, the preparation of vocational teacher candidates (pre-service vocational teachers) through education and training based on real experience in the industry is very important.

The vocational skills of pre-service teachers can be obtained through experience and training in their vocational field. In Indonesia, training and education programs for the pre-service teacher are mostly carried out through formal education (e.g., universities providing teacher training programs) and non-formal education (e.g., training pre-service teachers to obtain professional teacher certification). In the context of this study, it highlights the importance of managing teacher candidate education through formal education in higher education. Empirically, the implementation of apprenticeships for pre-service teachers is often carried out within the scope of educational institutions or schools. The concept of apprenticeship implemented in schools is focused on developing teaching skills. Apprenticeships in schools highlight how to provide teaching experience for pre-service teachers in schools. However, in the context of vocational education, apprenticeship in schools is not enough to prepare professional vocational teachers. Vocational teacher candidates should be involved in apprenticeship programs implemented in the industry to enhance vocational skills (e.g., Automotive Engineering skills). Unfortunately, providing real experiences to improve vocational skills (e.g., skills in repairing and maintaining automotive engines) has not been widely discussed and evaluated. Strengthening vocational skills for pre-service teachers will be effective if implemented in the industry through apprenticeship programs.

The learning model through the apprenticeship program has similarities to the problem-based learning model. Both of these learning models highlight the importance of real experience-based learning (de Graaff and Kolmos, 2003; Handoyono et al., 2020; Suyitno et al., 2020a,b). In the context of vocational education, real experience-based learning is mandatory in educational institutions. Real experience gained through apprenticeship and solving vocational problems will encourage the creation of good vocational skills for students, especially in automotive engineering. Many studies prove that apprenticeship can enhance the mastery of vocational skills (Steedman, 2012; Andersson et al., 2015; Horn, 2016; Gessler, 2019; Mahfud et al., 2019b). Most industrial apprenticeship are aimed at students. However, the discussion of industrial apprenticeship programs for teachers and pre-service vocational high school teachers is still limited. Improving the vocational experience for teachers through industrial apprenticeship programs is very appropriate to provide real work experience for teacher candidates. Furthermore, this apprenticeship program will impact improving student learning in vocational schools.

Based on the previous theoretical database, developing an industrial apprenticeship model for vocational pre-service teachers is very important. Therefore, this study aims to develop the industrial apprenticeship model for vocational pre-service teachers in automotive engineering. Specifically, this study aims to design and test the effectiveness of the Work-Based Learning (WBL)-based industrial apprenticeship model for pre-service teachers of Automotive Engineering Education. This apprenticeship model for prospective teachers will solve the problem of being unprofessional and unprepared for pre-service teachers in teaching automotive engineering to vocational students.

Vocational Education Teacher

Vocational education learns special skills training that can be used in the workplace (job-oriented) (Pavlova, 2009). Meanwhile, general education studies general knowledge and is not specifically prepared to work. Usually, general education is prepared for further study. According to Prosser and Quigley (1949), vocational education is a comprehensive experiential concept for every individual who learns to succeed in work. In the context of WBL-T related to Prosser's theory that vocational education will be efficient if (1) the environment in which students are trained is a replica of the environment in which they will work later, (2) it can only be given where training tasks are carried out by means, tools and machines used the same as that which is appropriate in the workplace, (3) he trains a person in the habit of thinking and working following what is needed in the workplace. Evans and Herr (1978) defines vocational education as part of the education system that prepares a person to be better able to work in one workgroup or one field of work than in other areas of work.

According to Hansen in Billet (2011), "vocational does not imply a one-way subordination of the person to the practice. Vocation describes work that is fulfilling and meaningful to the individual, such that it helps to provide a sense of self, of personal identity." Meanwhile, according to Kuswana (2013), vocational education is education held at an institution in educational institutions (secondary, post-secondary technical colleges) controlled by the government or industrial society. In this sense, vocational education can be carried out by government-owned and non-government schools and implemented in training educational institutions or community skills institutions. The basis used is to form Students' work readiness to get jobs according to their respective abilities.

The implementation of vocational education cannot be separated from the role of the teacher. Teachers are the primary key to successful learning in vocational schools. Teachers are considered "true gatekeepers" (Ertmer et al., 2012) of digital transformation in schools. In the context of learning, current vocational high school teachers are academically educated as vocational high school teachers with limited industrial experience. This little experience makes vocational high school teachers more textbook-oriented and academic, so they tend to enjoy more theoretical learning patterns. Vocational teachers are required to have the ability not only to teach theory in class but also to educate, teach, train, and guide students to enter the world of work (Bakar, 2018). Reforms in the field of vocational teacher education require changes in the character of teachers who are creative and innovative. This character is important to be able to compete in a global era that demands a high level of adaptation to change.

In general vocational teachers are expected to have work experience and qualifications in their vocational teaching subjects; there are often recruitment channels other than those used for academic teachers (Andersson et al., 2013; Fejes and Köpsén, 2014). In addition, Swedish vocational teachers must have formal vocational education and extensive work experience; that is, a solid vocational identity is required. However, formal teacher qualifications can be obtained through in-service training (Lucas and Unwin, 2009). According to Cedefop (2009), the activity appears to be designed for general education and does not cover specific vocational pedagogies.

Work-Based Learning

Brite (2013) defines the concept of WBL as learning that combines learning in the classroom and industry. They jointly design learning activities carried out in the world of work. WBL is implemented in Vocational High Schools by carrying out industrial work practices in its application. Raelin (2008) said that WBL combines theory learning with training and knowledge with experience. Students can learn directly from practical experiences planned according to the program of expertise they are interested in.

There are four advantages when conducting WBL programs: benefits for students, workers, schools, and communities (Brite, 2013). WBL is one of the learning models considered suitable for improving student and pre-service vocational teachers' competence. These competencies include competencies from aspects of knowledge, attitudes, and skills. These three aspects are critical competencies in preparing pre-service vocational teachers before entering the real teaching in vocational school.

Several forms of WBL include apprenticeship, cooperative educational placement, internships, school-based enterprise, service learning, and job shadowing (Boud and Solomon, 2001). Empirically, apprenticeship is considered one of the suitable learning approaches in vocational education (Mahfud et al., 2017). In this study, industrial apprenticeship for pre-service vocational teachers plays a role in preparing students who are skilled in their field of expertise. The apprenticeship model for pre-service vocational teachers is carried out in the workplace (in the industry) for a certain period. The involvement of pre-service vocational teachers in this program will encourage the improvement of skills that are needed for the teaching process in schools.

MATERIALS AND METHODS

Development Model

This study uses an Education Research and Development approach. Development research is defined as a systematic study in the design, development, and evaluation of programs, processes, and teaching products that must meet the criteria of validity, practicality, and effectiveness. The development model in this study went through the stages of the conceptual model, theoretical model, hypothetical model, and final model. The conceptual model is an analytical model, which mentions the product components, analyzes the features in detail, and shows the relationship between the elements to be developed. The theoretical model is a model that describes a framework of thought that is based on relevant theories and is supported by empirical data. The hypothetical model is a model that has received input from experts and practitioners through Focus Group Discussions (FGD). The final model is a model that has been empirically tested with extensive trial experiments.

Work-Based Learning-Based Industrial Apprenticeship Development Procedure

The WBL-based industrial apprenticeship model for pre-service vocational teachers was developed through analysis and study of several development models related to this study. Among these are the developments carried out by Gall et al. (2003). The model developed by Gall et al. (2003) consists of 10 steps (see **Figure 1**).

Product Trial Design

Product trials are carried out after validation and revision. Then, a fit and good model is obtained. The trial was conducted to determine whether the model is more effective than the old/conventional model. Therefore, the test was carried out by experiment, namely comparing the effectiveness of the old/traditional model with the WBL-based industrial apprenticeship model. The variables of the effectiveness of the WBL-based industrial apprenticeship model include work readiness which consists of indicators in it.

Model Development Trial Design

The trial was conducted using a quasi-experimental method to compare the two groups between the control group and the experimental group. The trial design was a randomized pre-test-post-test control group design (see **Table 1**).

The measurement of the effectiveness of the work model is done by testing the differences in work readiness competencies in the experimental and control groups. Indicators of job readiness competencies that are measured include aspects of knowledge, attitudes and skills. The knowledge aspect is seen from the 11 indicators as follows: (1) maintenance/service of the engine and its components, (2) overhauling the cooling system and its components, (3) maintenance/service of the gasoline fuel system, (4) repairing brake system, (5) repair wheels and tires, (6) maintain transmission, (7) repair clutch unit and components, (8) repair differential system, (9) repair steering system, (10) repair ignition system, (11) repairing minor damage to the electrical circuit/system, safety.

Meanwhile, competence from the aspect of attitude includes eight indicators: (1) motivation at work; (2) responsibility; (3) the ability to work together; (4) discipline; (5) initiative; (6) creativity; and (7) individual independence, (8) problem-solving ability. Meanwhile, competence from the skill aspect includes 11 indicators, including: (1) maintenance/service of the engine and its components, (2) overhauling the cooling system and its components, (3) maintenance/service of the gasoline fuel system, (4) repair the brake system, (5) repair the wheels and tires, (6) maintain the transmission, (7) repair the clutch unit and components, (8) repair the differential system, (9) repair the steering system, (10) repair the ignition system, (11) repairing minor damage to electrical circuits/systems, safety.

Techniques and Instruments of Data Collection

The research instrument is a measuring instrument used to collect data. According to the development stage of the WBL-based industrial apprenticeship model, it can be grouped into three. The study activities started with preliminary studies, model development instruments, and instruments to measure their effectiveness (see **Table 2**).

Data Analysis

Data analysis techniques include data analysis of model development and analysis of experimental data. Analysis of the model development data was carried out with qualitative descriptive analysis and quantitative descriptive analysis. In addition, hypothesis testing in this study uses Multivariate Analysis of Variance (MANOVA). The multivariate test aims to determine the effect of using the learning model on knowledge, attitudes and skills, in general/overall, or in other words, used to test the primary hypothesis—data analysis using SPSS for Windows software support. The multivariate test has four statistical methods: Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root. Hypothesis decision making criteria is if Sig. > 0.05, then the hypothesis is rejected. On the other hand, if Sig. 0.05, then the hypothesis is accepted.

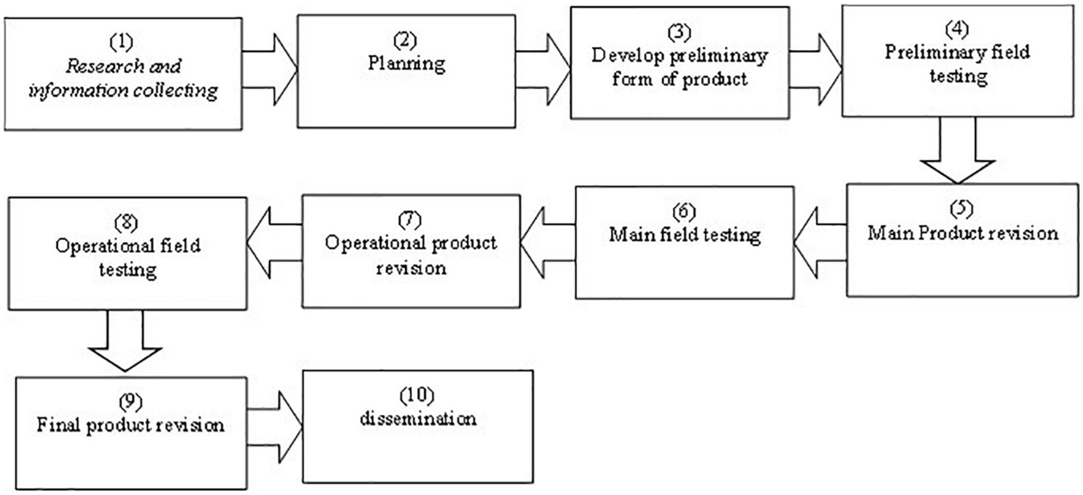

FIGURE 1 | Research and development models.

TABLE 1 | Pre-test and post-test research design.

Group	Pre-test	Treatment	Post-test
Control	O1	XA	O2
Experiment	O3	XB	O4

O1, O3, pre-test; O2, O4, post-test; XA, WBL-based industrial apprenticeship; XB, conventional apprenticeship.

FINDING AND DISCUSSION

This study focuses on developing a WBL-based industrial apprenticeship model for pre-service teachers of Automotive Engineering Education and comparing the effectiveness of the WBL-based industrial apprenticeship model with the conventional industrial apprenticeship model for teacher candidates. In the first stage, this study develops an industrial apprenticeship model based on WBL for pre-service teachers of Automotive Engineering Education. At this stage, data were obtained through an interview process with experts in vocational education.

Work-Based Learning-Based Industrial Apprenticeship Model for Pre-service Vocational Teacher in Automotive Engineering

Developing a WBL-based industrial apprenticeship model for pre-service automotive engineering teachers uses the basic philosophy of existentialism and essentialism as a reference. These two philosophies encourage vocational education to be linked with other systems such as economic, political, social, labor, and religious and moral (existentialism). Vocational education must also develop vocational education based on the fundamental human needs to live.

Based on the results of a focus group discussion (FGD) involving expert judgment, the results of the study show that the WBL-based industrial apprenticeship model for pre-service vocational teachers in the automotive engineering field consists of 2 phases. The first phase, the learning activities of pre-service teachers are carried out in universities. Learning activities on this campus include planning, implementation, evaluation, and reflection. In learning planning activities at universities, lecturers and industrial instructors coordinate with the aim of equalizing perceptions about time, instructors, apprenticeship places, programs, site selection, lesson plans, rules, and evaluations. Furthermore, in implementation activities on campus, learning activities are carried out through material presentations, training guidance, feedback, and conclusions and continued learning. At this stage, pre-service vocational teachers are expected to master conceptually and theoretically related to the substance of teaching materials and apprenticeship activities that will be carried out in industry.

At the stage of analyzing and evaluating, the lecturer helps pre-service vocational teachers to reflect or assess pre-service vocational teacher performance. This activity is carried out through examinations or tests to see the achievement of aspects of knowledge and skills and observations to evaluate aspects of attitudes. In the final stage, namely reflection, the lecturer invites pre-service vocational teachers to reflect on the learning process on campus as a step to prepare for apprenticeship in the industry.

Furthermore, in the second phase, pre-service vocational teachers learning activities are carried out through industrial apprenticeships in the automotive engineering field. This industrial apprenticeship includes planning, learning/work processes, monitoring, problem-solving, reflection, and evaluation (see **Figure 1**). Industrial lecturers and instructors agree on the time and competencies to be taught in the industry at the planning stage. At the study/work process stage, pre-service vocational teachers are fully involved in the work process in the automotive engineering industry. In

TABLE 2 | Matrix of R and D phase research methods.

No	Development stage	Aim	Subject	Method	Instrument
1	Preliminary studies	Obtaining information about model problems and requirements	A total of 20 pre-service vocational teachers and 3 industries	Interviews and surveys	Interview guide and questionnaire
2	Model Development	Model validation with FGD Expert judgment		Descriptive	Validity Questionnaire
3	Effectiveness	Comparing the finished model with the previous one	There are 60 pre-service vocational teachers and 12 industries	Experiment	Knowledge and skill tests, as well as attitude questionnaires

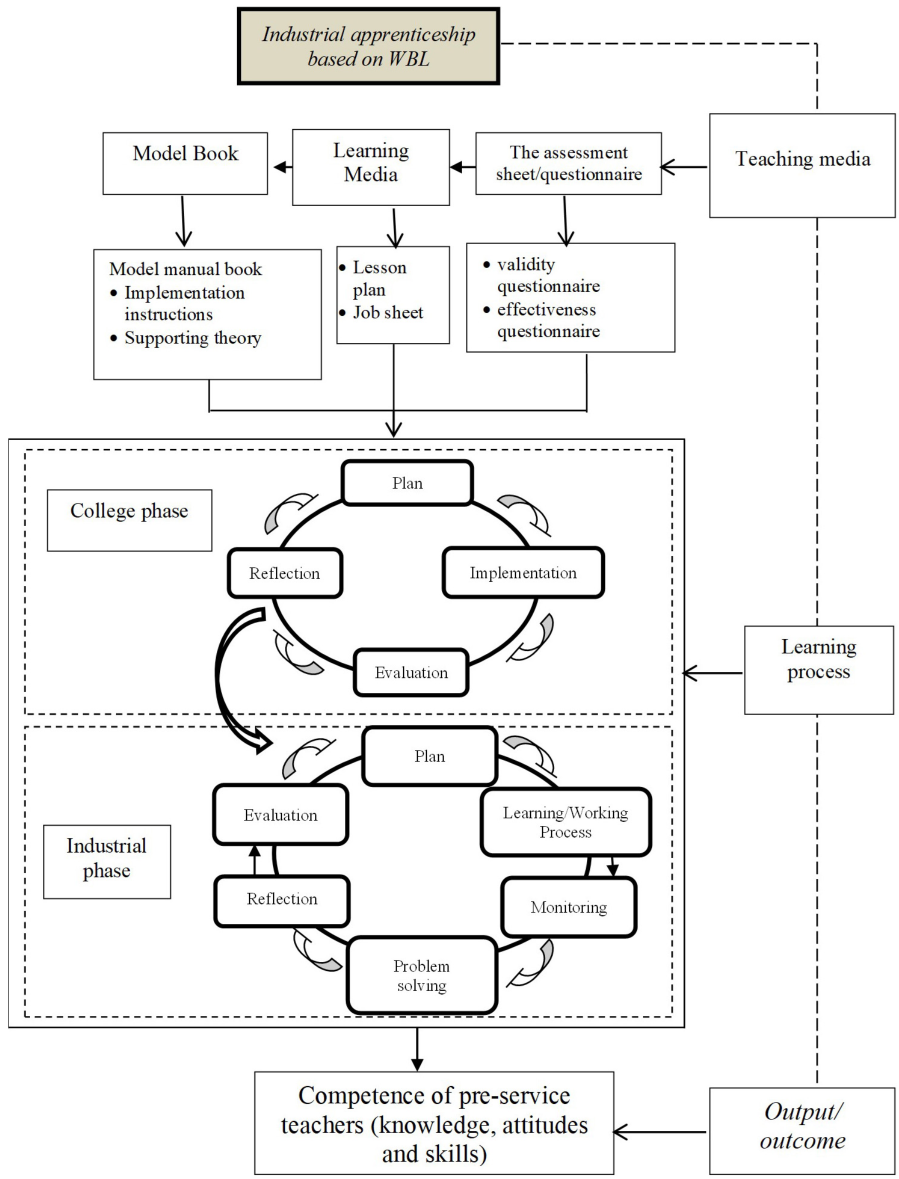

FIGURE 2 | Industrial apprenticeship model for pre-service vocational teacher in automotive engineering.

addition, pre-service vocational teachers also get information related to the introduction of the industry. In monitoring activities, lecturers carry out monitoring activities for pre-service vocational teachers every 2 weeks. And in problem-solving activities, pre-service vocational teachers are involved in problem-solving processes that occur in the

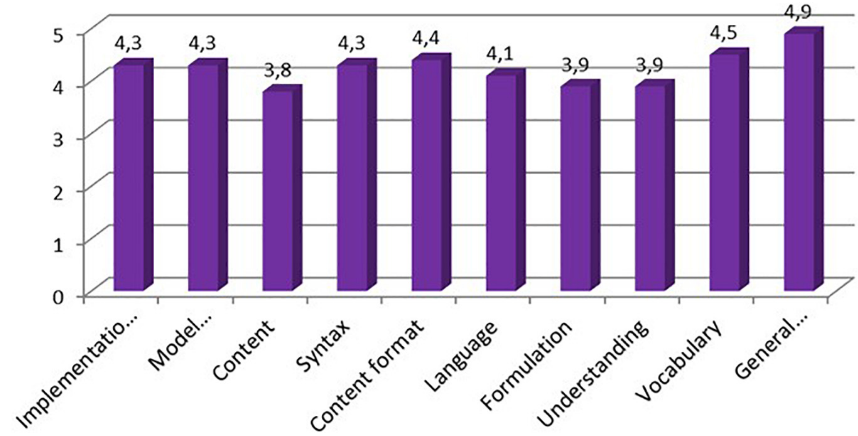

FIGURE 3 | Validation of the WBL-based industrial apprenticeship learning guide model for pre-service vocational teachers.

industry with lecturers and industrial instructors. Finally, in this second phase, namely industrial apprenticeships, a reflection process is carried out as an evaluation process related to industrial apprenticeship activities for pre-service teachers or automotive engineering students. The method of industrial apprenticeship activities for pre-service vocational teachers in automotive engineering is shown in **Figure 2**.

The industrial apprenticeship learning process for pre-service teachers encourages pre-service vocational teachers to learn pedagogical content about the teaching process (how to transfer knowledge) and vocational content (vocational skills). The process of preparing pre-service vocational teachers to understand and master teaching skills is carried out through classroom learning in universities. Meanwhile, providing vocational skills on automotive engineering skills is obtained through an apprenticeship in the automotive engineering industry. Apprenticeship activities in the industry are carried out for 3 months. Thus, pre-service vocational teachers are expected to be ready for pedagogical and vocational skills to become automotive engineering teachers.

The implementation of this apprenticeship model is equipped with a set of WBL guide model files for industrial apprenticeships, including instruments, learning tools, and model books. From the instrument, it is translated into the model's contents, including the instrument of validity and instrument of effectiveness. At the same time, the learning tools are lesson plans and job sheets, and from the model book, model guidebooks, implementation instructions, and supporting theories are made.

Model Product Testing and Model Testing in the Industry

The WBL-based industrial apprenticeship learning guide model that has been compiled is continued with model testing through expert judgment assessment. Model validation includes an evaluation of the feasibility of the model, which consists of the basis of implementation, model components, syntax, content format, language, formulation, understanding, vocabulary, and general assessment. The assessment of each indicator uses a Likert rating scale of 1–5. The results of model validation show that the feasibility indicators of the apprenticeship model include the basis for implementation model, model components, syntax, content format, language, formulation, understanding, vocabulary, and general assessment have a proper evaluation (see **Figure 3**).

In addition, the industrial apprenticeship model for pre-service teachers is assessed for use in the implementation of industrial apprenticeships for automotive engineering pre-service vocational teachers. The study results reveal that the model has ease and clarity to be applied to industrial apprenticeships for pre-service automotive engineering teachers (85.33%) (see **Figure 4**). In addition, the apprenticeship model is considered to encourage collaboration between industry and universities (88%). And most of the pre-service vocational teachers agreed that the industrial apprenticeship model for pre-service teachers was applied (87.2%). Implementing this industrial apprenticeship model is very appropriate to provide real learning for pre-service vocational teachers to become automotive engineering teachers. The implementation of this apprenticeship model is very relevant to providing real learning experiences for students (Mahfud and Pardjono, 2012; Allan, 2014; Suyitno and Pardjono, 2018; Mahfud et al., 2020).

The findings in **Figure 4** are also reinforced by the results of the pre-service vocational teachers assessments shown in **Figure 5**.

The Effectiveness of the Work-Based Learning-Based Industrial Apprenticeship Model on Pre-service Vocational Teachers in Automotive Engineering

The final step is to see whether the industrial apprenticeship model has succeeded in preparing pre-service automotive engineering teachers who are skilled in their vocational fields; it is necessary to analyze the model's effectiveness.

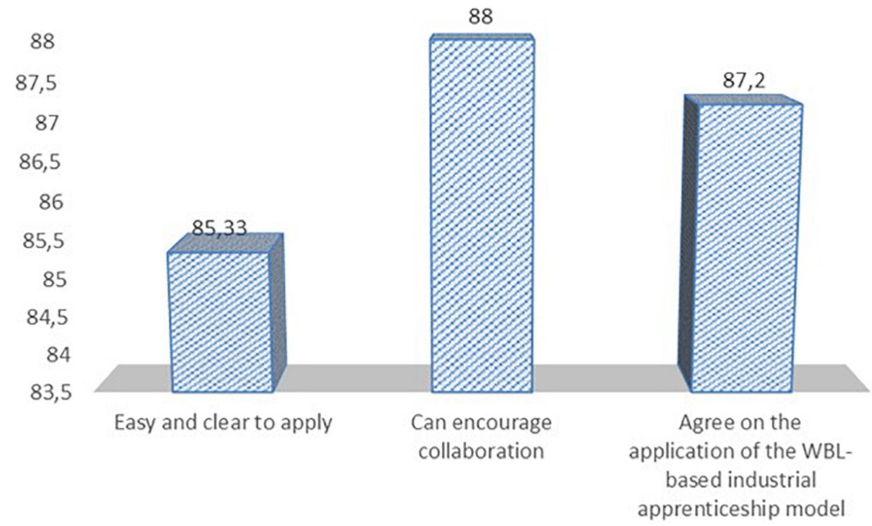

FIGURE 4 | The results of the applicability assessment of the apprenticeship model.

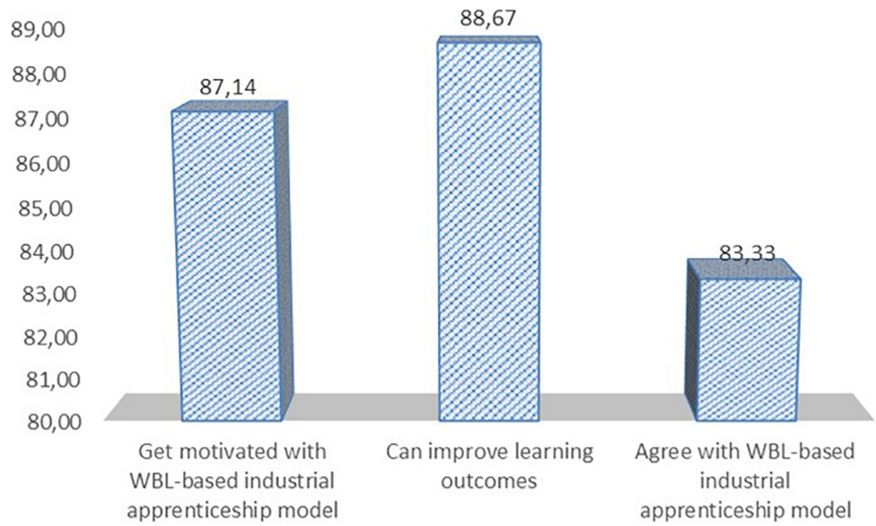

FIGURE 5 | Pre-service vocational teachers responses to the apprenticeship model trial.

The effectiveness of the apprenticeship model is done by analyzing the increase in the pre-test to post-test scores (gain score). Aspects of assessing the effect of applying the industrial apprenticeship model on improving the competence of pre-service teachers include aspects of knowledge, attitudes, and skills. The knowledge aspects set consist of (1) maintaining/serving the engine and its components, (2) overhauling the cooling system and its components, (3) maintaining/serving the gasoline fuel system, (4) repairing the brake system, (5) repair wheels and tires, (6) maintain transmission, (7) repair clutch unit and components, (8) repair differential system, (9) repair steering system, (10) repair ignition system, (11) repair minor damage to the circuit/electrical system, safety.

The results of the descriptive analysis of the effect of applying the WBL-based industrial apprenticeship model and conventional industrial apprenticeship on increasing knowledge of automotive engineering are shown in **Table 3**. The study results show that there is an increase in the score between the pre-test and post-test scores. Changes in value dominate an uptrend and positive value. This finding means that the application of the WBL-based industrial apprenticeship model impacts increasing pre-service vocational teacher's knowledge scores about light vehicle automotive engineering. Previous studies have also stated that apprenticeship supports individual development (Lave and Wenger, 1990) and offers daily work experiences to develop work knowledge (Billett, 2014). The WBL-based industrial apprenticeship experience for

TABLE 3 | The results of the pre-test and post-test knowledge on industrial apprenticeship.

No	Category	Score range	Learning model			
			IA-WBL		IA (traditional)	
			Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)
1	Very high	91–100	0.00	0.00	0.00	0.00
2	High	76–90	3.33	73.33	0.00	10.00
3	Moderate	61–75	26.67	26.67	26.67	80,00
4	Low	≤60	70.00	0.00	73.33	10.00

IA-WBL, WBL-based industrial apprenticeship; IA, traditional industry apprenticeship.

TABLE 4 | Results of pre-test and post-test attitudes on industrial apprenticeship.

No	Category	Score range	Learning model			
			IA-WBL		IA (traditional)	
			Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)
1	Very high	91–100	0.00	0.00	0.00	0.00
2	Tall	76–90	0.00	73.33	0.00	10.00
3	Currently	61–75	36.67	26.67	23.33	80.00
4	Low	≤60	63.33	0.00	76.67	10.00

IA-WBL, WBL-based industrial apprenticeship; IA, traditional industry apprenticeship.

TABLE 5 | Results of pre-test and post-test skills on industrial apprenticeship.

No	Category	Score range	Learning model			
			IA-WBL		IA (traditional)	
			Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)
1	Very high	91–100	0.00	10.00	0.00	0.00
2	Tall	76–90	0.00	90.00	0.00	3.33
3	Currently	61–75	6.67	0.00	20.00	90.00
4	Low	≤60	93.33	0.00	80.00	6.67

IA-WBL, WBL-based industrial apprenticeship; IA, traditional industry apprenticeship.

pre-service vocational teachers in the industry provides insight and knowledge related to automotive mechanical engineering expertise. In particular, WBL-based industrial apprenticeships and traditional apprenticeships are different. The WBL industrial apprenticeship process has a learning flow that includes plans, learning/working processes, monitoring, problem-solving, reflection, and encouraging evaluation. Meanwhile, traditional internships only cover planning, implementation, and evaluation.

Furthermore, the influence of the application of WBL-based industrial apprenticeship on the attitudes of pre-service teachers includes aspects of (1) motivation at work; (2) responsibility; (3) the ability to work together; (4) discipline; (5) initiative; (6) creativity; and (7) individual independence, (8) problem-solving ability. Descriptively, the attitude assessment on industrial apprenticeships is shown in **Table 4**. When compared to the application of the two apprenticeship models, it is found that the application of WBL-based industrial apprenticeship has an increased test score than the group of pre-service vocational teachers involved in conventional industrial apprenticeship. This means that the application of WBL-based industrial apprenticeships has improved the attitudes of pre-service vocational teachers in automotive engineering.

This study analyzes the effect of implementing WBL-based industrial apprenticeships on improving the skills of pre-service teachers, which include (1) maintaining/service engines and their components, (2) overhauling the cooling system and its components, (3) maintaining/serving material systems gasoline fuel, (4) repair the brake system, (5) repair the wheels and tires, (6) maintain the transmission, (7) repair the clutch unit and components, (8) repair the differential system, (9) repair the steering system, (10) repairing the ignition system, (11) repairing minor damage to the electrical circuit/system, safety. The study results show that the application of WBL-based industrial apprenticeships improves pre-service teachers' automotive engineering skills. This can be seen in the score obtained by the group of pre-service vocational teachers involved in the WBL-based industrial apprenticeship program, which has a skill score that tends to increase compared to the conventional industrial apprenticeship group (see **Table 5**). Although the pre-service vocational teachers involved in the traditional apprenticeship program saw an increase, most were in the moderate category (61–75).

The final step of testing to determine the effectiveness of the WBL-based industrial apprenticeship model is a different test using multivariate analysis (Multivariate Analysis of variance, MANOVA). MANOVA testing includes Multivariate Test and Test of Between-Subject Effect. The Multivariate Test was used to determine the differences between the WBL-based industrial apprenticeship model and the conventional industrial apprenticeship model in improving the competence of pre-service automotive teachers. Meanwhile, the Test of Between-Subject Effect is used to determine the differences between the WBL-based industrial apprenticeship model and the conventional industrial apprenticeship model in improving automotive teacher candidates' knowledge, attitudes, and skills competencies.

The Multivariate Test showed the acquisition of $t = 14.521$ (Sig. = $0.000 < 0.05$). This means that there are differences in the WBL-based industrial apprenticeship model and conventional industrial apprenticeship to improve the competence of automotive teacher candidates. Pre-service vocational teachers who use the WBL-based industrial apprenticeship model have better competencies than conventional industrial apprenticeships. This shows that the WBL-based industrial apprenticeship model is more effective than conventional industrial apprenticeships. Furthermore, the analysis is continued to determine the effectiveness of the improvement in every aspect of competence, including knowledge, attitudes, and skills.

The study results reveal that the knowledge aspect has a value of $F = 10{,}171$ (Sig. = 0.000 0.05); this means that there are differences in the WBL-based industrial apprenticeship model and conventional industrial apprenticeship to improve the knowledge competence of automotive teacher candidates. In addition, in the attitude aspect, it is known that the acquisition value of $F = 59$ (Sig. = 0.000 0.05), means that there are differences in the WBL-based industrial apprenticeship model and conventional industrial apprenticeship to improve the attitude competence of automotive teacher's candidates. In the skill aspect, the value of $F = 59$ (Sig. = 0.000 0.05), this finding also means that there are differences in the WBL-based industrial apprenticeship model and conventional industrial apprenticeship to improve the competency skills of automotive teacher candidates. The overall hypothesis test shows that applying the WBL-based industrial apprenticeship model can enhance the competency of pre-service automotive engineering teachers, including knowledge, attitudes, and skills.

The findings of this study reinforce previous studies which revealed that apprenticeship can positively maintain and develop the knowledge and skills of pre-service workers in the industrial world (Taylor and Watt-malcolm, 2007). In addition, apprenticeships also encourage individual development and work experience (Lave and Wenger, 1990; Billett, 2014). Workplace learning is the right learning model to provide work experience related to vocational fields. Pre-service vocational teachers are not only sufficient to master pedagogic abilities but must have vocational skills in their field, for example in the context of this study in automotive engineering. Therefore, cooperation between vocational education institutions and industry, especially in terms of implementing apprenticeships, is very important and even absolutely necessary to be developed and improved continuously (Andersson et al., 2015). The existence of an apprenticeship program that demands to be held in the workplace has consequences for increasing cooperation in terms of drafting cooperation agreements involving relevant stakeholders, namely educational institutions (e.g., universities), companies, and pre-service vocational teachers. Universities must have an apprenticeship model design in two different scopes. First, apprenticeship, which aims to strengthen teaching skills, is carried out in vocational high schools. Second, apprenticeships to improve vocational skills (e.g., automotive engineering) are carried out in the automotive industry. The two apprenticeship programs must be able to develop tastefully to strengthen skills as prospective professional vocational teachers. Good management of the apprenticeship program, especially for pre-service teachers, will encourage the preparation of pre-service vocational teachers who are skilled in their pedagogic and vocational aspects. The program for strengthening the competence of vocational teachers in the form of upskilling or reskilling in the workplace needs to be regularly scheduled by the government to update technological developments in the workplace.

CONCLUSION

The WBL-based industrial apprenticeship model for pre-service vocational teachers plays an essential role in improving vocational skills for pre-service vocational teachers. The implementation of WBL-based industrial apprenticeships can improve the competence of pre-service automotive engineering teachers, which includes knowledge, attitudes, and skills in the field of automotive engineering. The results of this study have implications for vocational education practitioners, especially higher education that organizes teacher education programs, to apply this apprenticeship model in preparing pre-service vocational teachers. This study has limitations, namely the limited involvement of respondents, which impacts the difficulty of generalizing a wider context. Therefore, in future research, it is necessary to research a broader scope to test the effectiveness of the apprenticeship model for prospective teachers. For example, it involves testing the apprenticeship model on similar schools in the same province.

DATA AVAILABILITY STATEMENT

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Ethical review and approval were not required for the current study in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

SS: instrument development, data analysis, manuscript review, and manuscript submitting. YK: data analysis and manuscript writing. DJ: data collection. MN: data collection and manuscript writing. ES: data collection and manuscript editing. All authors contributed to the article and approved the submitted version.

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