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Development of Instruments to Measure Automotive Electrical Competency

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ABSTRACT
Objective: Competence is an individual's ability to do a job adequately and appropriately. Competence is needed in the field of work. Future vehicles are currently heading towards electric-based vehicles. Therefore, graduates who have competence, especially in electricity, are needed. Valid and accurate measuring instruments are needed to determine a person's competence. Therefore, in this study, instruments were developed to measure student competence in automotive electricity. **Method:** The research method used is a development study using a 4D model consisting of four phases: Defining, Designing, Developing, and Disseminating. The finished instrument is validated and tested to see its validity and reliability. **Results:** This study obtained automotive electrical competency instruments in 3 instruments, namely to measure knowledge, skills, and attitudes. There is 1 question item that must be dropped because the CVR value and correlation test items are below 0.3, and the outfit and infit values are above 2. No question items are dropped for instruments, indicators, attitudes, and skills. All automotive electrical competency instruments produce reliable instruments. **Novelty:** a unique instrument that focuses on automotive electrical competence. This approach includes knowledge, skills, and attitudes towards technological developments.

INTRODUCTION

Vocational education is integral to the education system in providing learners with practical skills and knowledge to prepare for workforce entry. This education focuses on teaching specific skills and knowledge relevant to a particular industry. Around the world, vocational education has been recognized as a key pillar for addressing the skilled labor shortage and meeting the demands of an ever-growing job market (Ariyani et al., 2021). One of the challenges of vocational education is technological advancement. VHS graduates must be able to follow these developments by preparing the knowledge, skills, and attitudes needed by the world of work (Wagiran et al., 2020). This aligns with Rojewski's opinion that vocational education is highly challenging in developing, adapting, or redesigning strategies to address the needs of work and society. In addition, the challenge of vocational education is the stigma of society that still considers vocational education as a second choice compared to formal education is also an obstacle (Danilov, 2022; Kholifah et al., 2022). This results in prospective students' lack of interest in vocational education, even though the industrial sector requires a workforce with specific skills. Therefore, collaborative efforts between government, industry, and educational institutions are needed to improve the quality and relevance of vocational education so that it can meet the demands of a dynamic market (Kilag et al., 2023; Maryanti et al., 2020; Munir et al., 2022; Ozer, 2021; Suharno et al., 2020). Vocational High School (VHS) graduates should be able to start their careers immediately after completing training using their existing skills (Inderanata & Sukardi, 2023; McGrath & Yamada, 2023).

However, the unemployment rate of VHS graduates is still the highest compared to other education graduates. Data from the Central Statistics Agency (BPS) in 2022 regarding employment in Indonesia, primarily vocational graduates, using employment survey data conducted by BPS, states that VHS graduates are the most unemployed (Badan Pusat Statistik, 2022). The Central Statistics Agency (BPS) shows the number of unemployment vacancies at 8.4 million even in February 2022. VHS alums are the largest compared to alums of other education levels. According to Mutaqin, less than half of VHS graduates are absorbed in the automotive field, especially in the light vehicle engineering expertise program category. One of the main problems is the gap between the educational curriculum and the actual needs of the job market. Many vocational education institutions have yet to adapt quickly to technological developments and industrial innovations, so graduates are often faced with difficulties when entering the world of work (Boruah, 2022; Mitchell & Buntic, 2022; Sukianto, 2022).

A competency is a specific ability or qualification acquired through education, training, or experience. This enables them to effectively complete a task or problem in a professional or academic context. Competency in a vocational field indicates an individual's ability to carry out certain tasks or activities related to a specific skill area. In this context, competence includes theoretical knowledge, practical skills, professional attitudes, and an in-depth understanding of relevant procedures or techniques (Derco & Tometzová, 2023; Heldal et al., 2023; Perisic et al., 2023). For example, in vocational fields such as automotive mechanics, competence includes diagnosing, maintaining, and repairing vehicles efficiently and precisely. In addition, within vocational fields, competencies are often defined by industry standards, certifications, or qualification frameworks that identify the skills and knowledge required to succeed in a particular profession. Competence in vocational areas ensures a high quality of work and improves safety, efficiency, and innovation in the industrial sector (Abdurrahman et al., 2022; Grabowska & Saniuk, 2022; Poláková et al., 2023). Therefore, competency development and assessment become crucial in vocational education to prepare individuals with relevant skills required by a dynamic and rapidly evolving job market.

It has yet to apply industry-level expertise standards in the VHS environment, one of which is during the implementation of the Competency Test in class XII. The implementation of competency tests in class XII refers to the National Professional Certification Board, where the implementation is based on the selection of competency test packages. Each competency test package contains the competence of engine, chassis, and electrical expertise. Because three expertise competencies are in one package, it takes a long time. This long time results in the stress level of students in conducting exams, so the competency test results are less than optimal (Abdurrahman et al., 2022)

Measuring competence requires a systematic and comprehensive approach that includes three leading indicators: knowledge, skills, and attitudes (Jeah, 2022; Misbah et al., 2019; Sudradjat & Djanegara, 2020). First, in knowledge, evaluation is carried out to assess a person's understanding and theoretical expertise in a field or discipline. This could involve written tests, quizzes, or research projects to gauge how much a person understands relevant concepts, theories, and principles. Second, skill refers to a person's ability to apply knowledge in a practical context or actual situation. Skill evaluation usually involves the assessment of practices, simulations, or field projects that allow individuals to demonstrate their ability to effectively take action, solve problems, or perform specific tasks. Third, attitudes reflect a person's behavior, values, and mental orientation in handling professional or personal situations. Attitude assessment often requires observation, interviews, or self-assessment to assess aspects such as work ethic, teamwork, responsibility, and adaptability. By considering these three indicators holistically, competency measurement becomes more comprehensive and provides a more accurate picture of a person's abilities in diverse and dynamic contexts.

To determine the achievement of competence, especially in automotive electricity, it is necessary to develop instruments based on existing conditions in the industrial world. Assessments that can be used to measure automotive electrical competence are performance tests. Assessments that can be used to measure scientific thinking skills are called performance appraisals. With performance appraisals, students can apply their skills to solve real-life tasks and problems. Performance appraisals ask students to demonstrate and apply knowledge in contexts that fit specified criteria (Darling-Hammond & Hyler, 2020; Deschênes, 2020; Miller, 2021; Ngereja et al., 2020). In addition, performance appraisal requires students to work, do, and demonstrate their abilities so that they do not just answer questions and do not choose available answers. Therefore, it is essential to use student performance assessments to measure the competence of his skills.

No instrument precisely measures automotive electrical competence with three aspects: knowledge, skills, and attitudes. On the indicators of knowledge and skills, everything is based on problem-solving skills. In addition, work attitudes in the process of doing work are assessed based on criteria that have been made. It is expected that the development of this instrument, which concerns three indicators, will be able to measure student competence, especially in automotive electricity.

This research focuses on measuring technical knowledge or skills and incorporates dimensions of student attitudes. This is an essential aspect of vocational education, where professional attitudes and work ethics also need to be evaluated to prepare students to become a qualified workforce. The results of this study have far-reaching implications for vocational education, especially in developing evaluation instruments that are more comprehensive and relevant to industry demands. By paying attention to aspects of knowledge, skills, and attitudes in competency measurement, vocational education can be more effective in preparing students to enter the workforce.

RESEARCH METHOD

The method used in this study is Research and Development (R&D). The research procedure adopts a 4D development model consisting of four phases: Define, Design, Develop, and Disseminate, and is limited to the development stage only in Figure 1. The study was conducted from September to October 2023.

Automotive electrical competency instrument validation data was obtained from experts, consisting of 4 teachers in the field of expertise and three practitioners using validation sheets. The results of the validators will be analyzed using CVR (Content Validity Ratio). The instrument can be maintained where the CVR value ≥ 0.30 (Basirimoghadam et al., 2023; Marar et al., 2023). After improving the instrument based on the advice of the validator, then the instrument is ready for testing.

The instrument trial was carried out at VHS 1 Sidayu, Gresik Regency. The research subjects were class XII Automotive Light Vehicle Engineering students, as many as 32.

The trial results are then analyzed for the item correlation of each item. The question item is void if the CVR value is < 0.30 and the item correlation is < 0.30. In addition to being observed from item correlation, it is also analyzed from Unweighted Fit MNSQ (OMS) and Weighted Fit MNSQ (IMS). If the IMS and OMS values are above 2, the item breaks the measurement system/invalid item.

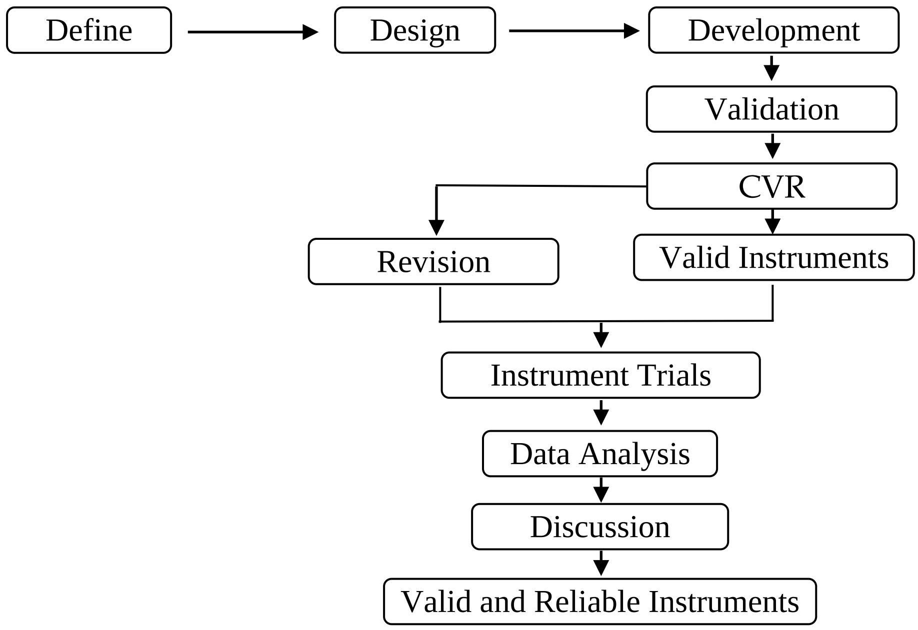

Figure 1. Research flowchart.

RESULTS AND DISCUSSION

Results

This research uses the 4D development method but is limited to the development stage. The results obtained in this study are as follows.

1. Define

   The defining phase not only collects various information related to the developed product but also helps identify and define needs in the learning process. This phase is divided into several steps.

   a. Students as research subjects are students who have taken automotive electrical subjects, namely class XII.

   b. Task analysis aims to analyze the main tasks to be performed by learners. The analysis consists of essential competencies related to automotive electrical competencies.

   c. The concept analysis aims to ascertain the content of the performance test instrument to measure the competence of automotive electricity to be developed.

2. Design

   After obtaining problems from the defining stage, the design stage is continued. This design stage aims to design performance tests to measure automotive electrical competence. This design stage includes preparing tests based on objectives that will be a benchmark for automotive electrical competence. Competence can be seen from 3 indicators: knowledge, skills, and attitudes. Therefore, there are three instruments for measuring automotive electrical competence. On the indicators of knowledge of the instrument used is a test in the form of multiple choice. Indicators on skills in automotive electrical competence using performance test instruments. As for attitude indicators using observation instruments. The respective grids of these instruments are as follows.

a. Competency instrument grid

Table 1. Instrument grille automotive electrical competence knowledge indicator.

Variable	Indicator	Sub Indicators	Question Form	Number of Questions
Automotive electrical competence	Knowledge (Cognitive)	1. Perform maintenance on car electricity	Multiple Choice	3
		2. Evaluate the results of periodic electrical maintenance of light vehicles	Multiple Choice	3
		3. Implementing stater system maintenance	Multiple Choice	3
		4. Diagnosing a charging system malfunction	Multiple Choice	3
		5. Diagnosing a malfunction of a conventional ignition system	Multiple Choice	4
		6. Diagnosing electronic ignition system malfunctions	Multiple Choice	3
		7. Diagnosing air conditioning (AC) system malfunctions	Multiple Choice	3
		8. Diagnose audio system malfunctions.	Multiple Choice	3

b. Competency instrument grid of skill indicators

Table 2. Instrument grille, automotive electrical competence, skill indicator.

Variable	Indicator	Sub Indicator	Question Form	Number of Questions	Question No
Automotive electrical competency	Skills (Psychomotor)	1. Repair ignition system	Performance Test	2	1, 2
		2. Improve the lighting system.	Performance Test	2	3, 4

c. Attitudinal indicator competency instrument grid

Table 3. Automotive electrical competency instrument grid for attitude indicators.

Variable	Indicator	Aspects observed	Number of Items	Item Number
Automotive electrical competency	Attitude (Affective)	1. Responsibility	2	1, 2
		2. Discipline	2	3, 4
		3. Accuracy	2	5, 6
		4. Honesty	2	7, 8

3. Development
   electrical capabilities in the automotive sector. The instrument was revised based on expert contributions and student experiments. This phase has two steps:
   a. Expert validation
      After preparing a draft instrument for automotive electricity for each dimension, the next stage is to validate the content. Content validation is carried out with the help of experts in their fields, especially in automotive electricity. The validation sheet for validators uses a linkage scale of 1-4; then, this scale is converted to scores of 0 and 1. If the validator's answer scores 3 or 4, it gets a score of 1, while an answer of 2 or 1 gets a score of 0.
      The results of the validation recapitulation of the knowledge, skills, and attitudes of automotive electrical competency instruments are as follows.

Table 4. CVR results of the automotive electrical competency instrument, knowledge indicators.

No item	CVR	No item	CVR
1	1.00	14	1.00
2	1.00	15	1.00
3	1.00	16	0.71
4	0.71	17	0.71
5	0.14	18	0.14
6	0.71	19	1.00
7	1.00	20	0.43
8	1.00	21	0.43
9	0.71	22	0.71
10	1.00	23	1.00
11	0.71	24	1.00
12	1.00	25	1.00
13	1.00		

Table 5. CVR results of the automotive electrical competency instrument, attitude indicators.

No item	CVR
1	1.00
2	0.71
3	1.00
4	0.43
5	0.43
6	1.00
7	0.71
8	1.00

Table 6. CVR results of the automotive electrical competency instrument, skill indicators.

No item	CVR
1	1.00
2	1.00
3	1.00
4	1.00

After obtaining validation data, the researcher revised several questions according to the validator's suggestions. The results of these improvements were then carried out in limited trials. The trial was carried out on 32 students of class XII automotive light vehicle engineering at VHS Negeri 1 Sidayu, Gresik Regency. The results of the automotive electrical competency instrument trials are produced in Table 7.

Table 7. Results of correlation test items, unweighted fit MNSQ, and weighted Fit MNSQ for automotive electrical competency instruments, knowledge indicators.

No	Item Test Correlation	Unweighted Fit MNSQ	Weighted Fit MNSQ
S1	0.78	0.56	0.71
S2	0.31	0.69	0.84
S3	0.52	0.73	0.96
S4	0.52	0.76	0.93
S5	0.20	2.90	2.27
S6	0.32	0.85	1.10
S7	0.50	1.15	1.04
S8	0.43	0.90	1.08
S9	0.37	1.21	1.29
S10	0.51	0.78	0.97
S11	0.53	0.79	0.95
S12	0.66	0.67	0.85
S13	0.78	0.55	0.69
S14	0.67	0.69	0.86
S15	0.53	0.79	0.95
S16	0.41	0.95	1.12
S17	0.81	0.50	0.64
S18	0.38	1.41	1.19
S19	0.48	0.75	0.95
S20	0.45	0.78	1.02
S21	0.50	1.15	1.04
S22	0.48	0.85	1.02
S23	0.68	0.66	0.83
S24	0.45	0.83	1.06
S25	0.52	0.73	0.69

Table 8. Results of correlation test items, unweighted fit MNSQ, weighted Fit MNSQ for automotive electrical competency instruments, attitude indicators.

Point	Item Test Correlation	Unweighted Fit MNSQ	Weighted Fit MNSQ
S1	0.70	0.93	0.96
S2	0.65	1.10	1.10
S3	0.50	0.98	0.96
S4	0.42	0.83	0.82
S5	0.65	1.07	1.07
S6	0.62	0.88	0.85
S7	0.23	1.19	1.20
S8	0.75	0.93	0.95

Table 9. Results of correlation test items, unweighted fit MNSQ and weighted Fit MNSQ automotive electrical competency instruments, skill indicators.

Point	Item Correlation Test	Unweighted Fit MNSQ	Weighted Fit MNSQ
S1	0.61	0.99	1.01
S2	0.69	0.88	0.87
S3	0.69	1.02	1.02
S4	0.48	1.23	1.19

Discussion

Development of automotive electrical competency measurement instruments using 4D models. The research procedure adopts a 4D development model, which consists of four phases: Defining, Designing, Developing, and Disseminating, and is limited to the development stage only. The automotive electrical instrument on the knowledge indicator obtained a CVR value below 0.2o for two questions, namely item numbers 5 and 18. After repairs were made, the instrument was tested. The trial results showed that one instrument had to be removed. The data summary can be seen in Table 10.

Table 10 Recapitulation of CVR, correlation test items, OMS, and IMS.

Point	CVR	Item Tes Correlation	OMS	IMS	Information
S5	0.14	0.20	2.90	2.27	Deleted
S18	0.14	0.38	1.4	1.19	Maintained

Item number 5 is omitted in the instrument. This does not meet the CVR, correlation test items, OMS, and IMS. However, in question number 18, only the CVR has yet to be met. After it had been repaired, the test results from the correlation, OMS, and IMS test items met the prerequisites. Therefore, question number 18 can be maintained in the automotive electrical competency instrument on the knowledge indicator. This instrument is also reliable. This can be seen from the Cronbach alpha value, namely 0.88. Automotive electrical instruments on the skill indicator contain four questions. These four questions can be used to measure automotive electrical competence on skill indicators. This can be seen from the results of the CVR, correlation test items, OMS, and IMS, which got scores in the standard range. Apart from that, the reliability value of the instrument was 0.53, which means that the instrument is reliable in measuring automotive electrical competence with skill indicators.

In the automotive electrical competency instrument on the attitude indicator, there are eight questions to carry out observational assessments. The validation results obtained a CVR value above 0.30 and tested the correlation, IMS, and OMS test item values within the specified standard range. This states that the instrument is valid. Meanwhile, the reliability level is 0.71, meaning the instrument is reliable. This research provides a comprehensive overview of developing automotive electrical competency measurement instruments using 4D models. This model has proven effective in producing valid and reliable instruments to evaluate students' knowledge, skills, and attitudes in the automotive field. The process of instrument development through the Definition, Design, Development, and Deployment stages provides a structured and scalable framework, which is essential to ensure the quality and relevance of the instrument (Julia et al., 2021; Larson et al., 2021; Linde et al., 2023; Mohammad & Mahjabeen, 2023; Stylidis et al., 2020). This research implies that the instruments developed can be a guideline for developing competency measurement instruments in other automotive fields. The recommendation for future research is to continue improving the instrument based on the evaluation carried out and pay more attention to the instrument's reliability in depth to increase confidence in the evaluation results obtained.

CONCLUSION

Fundamental Finding: Knowledge, attitudes, and skills indicators can measure automotive electrical competency. Each indicator uses a different instrument. Knowledge indicators use multiple choice test instruments, skill indicators use performance test instruments, and attitudes use observation instruments. **Implication:** Currently, competency measurement only focuses on skills. This instrument can measure students' competence more precisely, especially in automotive electricity, because it contains knowledge, attitudes, and skills. **Limitation:** The field of automotive electricity is pervasive, so the development of this instrument only focuses on the basic infrastructure and materials provided by each school. **Future Research:** The results of the development of this instrument will be used to carry out further research on what factors influence student competence, especially in automotive electrical competition.

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