Jurnal Kecerdasan Buatan dan Teknologi Informasi
Vol. 5, No. 3, September 2026, pp. 831–841
e-ISSN: 2964-2922, p-ISSN: 2963-6191

Open access

Original Research

Implementation of Simple Additive Weighting Algorithm for Student Skill Evaluation in SMK Cahaya Otomotif 2

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ABSTRACT

Skill evaluation processes at SMK Cahaya Otomotif 2 are currently conventional, resulting in unintegrated assessment data and difficulties in real-time monitoring. This study aims to develop a web-based e-learning system implementing the Simple Additive Weighting (SAW) algorithm to automate objective student skill assessments. The system was developed using the Waterfall model with the PHP programming language and CodeIgniter framework. Assessments are based on six main criteria: quizzes, forum engagement, practical tasks, attendance, mid-term exams, and final exams. Results indicate that the system accurately generates preference scores and automatically classifies student competencies into categories ranging from "Highly Competent" to "Needs Remedial". Validation using student operational data proves a perfect alignment between system and manual calculations, as shown in the 91.75 score sample. Black Box testing confirmed that all functional features operate validly. This implementation successfully enhances grading transparency for students and facilitates the school management in monitoring skill development measurably.

How to Cite:
A. N. Septiansyah and A. Ratnasari, "Implementation of Simple Additive Weighting Algorithm for Student Skill Evaluation in SMK Cahaya Otomotif 2," *J. Kecerdasan Buatan dan Teknol. Inf.*, vol. 5, no. 3, pp. 831–841, 2026.
Doi: https://doi.org/10.69916/jkbti.v5i3.606

KEYWORDS

E-Learning
Simple Additive Weighting (SAW)
Skill Evaluation
Vocational High School
Student

ARTICLE INFO

Received: July 29, 2026
Accepted: September 16, 2026
Available Online: September 23, 2026

1 INTRODUCTION

Digital transformation in the world of education has become an urgent necessity to improve the quality of learning through integrated e-learning systems [1]. Although this technology offers wide access flexibility, its implementation in various institutions still faces significant challenges regarding human resource readiness in adapting to new digital platforms [1]. In the context of vocational education, mastering technical competencies requires interactive learning media so students can master both theory and practice in a balanced and effective manner [2]. The importance of digital media innovation in increasing student achievement, specifically in complex vehicle engine systems, has been proven through the development of innovative interactive aids that provide clearer visualizations of mechanical components [2]. Furthermore, the use of electronic teaching materials in vocational school environments has been shown to provide a positive response toward increasing student learning independence significantly [3].

For specific technical competencies such as vehicle electricity, the development of specialized e-learning modules is considered highly feasible and effective in improving student understanding compared to traditional textbooks [4]. The integration of learning video content and a Learning Management System (LMS) is currently considered the most relevant solution for optimizing learning outcomes in vocational education, which possesses a high level of technical complexity [5]. However, the actual condition at many vocational high schools (SMK) currently shows operational barriers where the skill evaluation process is still conducted conventionally [6]. The implementation of digital learning is often hindered by variations in the technical abilities of teachers and the limitations of practical facilities that have not been digitally integrated into the curriculum [6].

Currently, practical workshop assessments often still use manual paper-based rubrics, which leads to evaluation data not being integrated into a centralized database for long-term tracking. Without a structured and automated evaluation system, the development of students' critical thinking skills will be difficult to measure accurately through independent learning media alone [7]. Consequently, the score recapitulation process becomes slow, documentation of student work (such as repair photos or videos) is disorganized, and teachers face difficulties in providing rapid, data-driven feedback to their students. A review of existing literature shows that current web-based module development still tends to focus on ease of access to materials without touching upon the critical aspect of objective automated assessment [8].

Although system design using Unified Modeling Language (UML) modeling has been widely carried out to improve institutional communication, intelligent evaluation features to measure technical competence deeply are still very rarely implemented [9]. The use of gamification methods can indeed increase learning motivation and engagement, but it still requires the support of a robust decision-making system to measure multi-criteria skill achievement accurately [10]. Most e-learning systems developed today, such as those built using PHP, are still limited to basic class administration functions and static material distribution [11]. Furthermore, web framework designs often only validate basic features and interface responsiveness without including sophisticated automated assessment features [12]. In fact, the digital competence of modern teachers urgently requires support from information systems that are capable of facilitating the automatic identification of student abilities [13].

As a solution to these problems, this study proposes the implementation of the Simple Additive Weighting (SAW) algorithm to automate student skill evaluation within an e-learning environment. The adoption of the SAW algorithm has been proven very effective as a decision support system in determining adaptive learning strategies through accurate multi-criteria weighting [14]. The use of this method, combined with the Waterfall development model, is expected to process practical and theoretical assessment data transparently to produce highly accountable competency reports [15]. This research aims to develop an e-learning system that implements the SAW algorithm as an automated competency evaluation tool and builds a platform that integrates material data, quizzes, and practical documentation into a single centralized database. Thus, the system is expected to provide a real-time overview of student skill development to the school through structured, transparent, and accountable reports.

2 RESEARCH METHODS

2.1 Research Design and Data Acquisition

This study applies a descriptive research approach to systematically define the requirements for an automated evaluation system at SMK Cahaya Otomotif 2. The research was carried out over a four-month period starting from February to May 2026. Data collection involved direct observation of workshop activities to understand the manual grading workflow used by teachers. Structured interviews were conducted with vocational teachers to identify specific technical hurdles in the current paper-based system. Additionally, documentation studies and questionnaires were distributed to students to measure their digital accessibility and specific learning needs. This comprehensive data gathering phase ensures that the developed system accurately addresses real-world educational challenges.

2.2 System Development Life Cycle (Waterfall)

The development of the e-learning system follows the structured Waterfall life cycle model to ensure a systematic progression. It begins with a detailed requirements analysis to define the specific needs and access levels of all system actors. The system and software design phase translates these requirements into technical blueprints and database relational structures. During the implementation stage, the actual coding is performed to realize the design into a functional web platform. Finally, the system undergoes rigorous testing and deployment phases to ensure it is stable and ready for institutional use. This linear methodology is chosen to maintain data integrity and minimize errors during the integration of the evaluation engine.

2.3 System Modeling

System modeling is performed using the Unified Modeling Language (UML) to manage architectural complexities effectively. The Use Case Diagram provides a visual representation of how different actors interact with the system's functionalities.

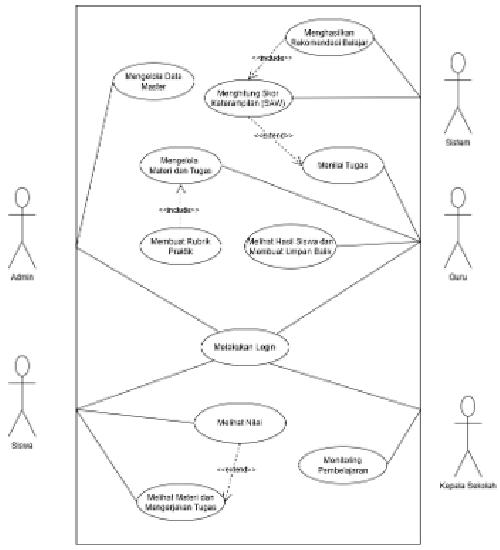

Figure 1. Use Case Diagram of the Proposed E-Learning System

Admin, Teacher, Student, and Principal are the four primary actors defined within this operational framework. Furthermore, the Class Diagram illustrates the relational database structure needed to support the automated assessment logic.

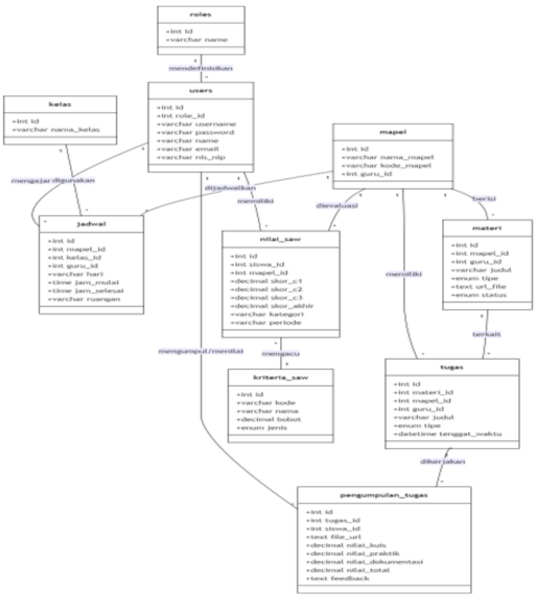

Figure 2. Class Diagram of the Evaluation System Database

This modeling phase ensures that the data flow between materials, tasks, and criteria scores is logically integrated. By using UML, the technical communication between developers and school stakeholders is greatly simplified.

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2.4 Proposed SAW Algorithm Implementation

The core evaluation engine of the system is built upon the Simple Additive Weighting (SAW) algorithm, a robust multi-criteria decision-making method. This algorithm processes six weighted criteria aligned with the vocational curriculum: Quiz (C_1), Forum Discussion Participation (C_2), Practical Task Performance (C_3), Attendance (C_4), Mid-term Exam (C_5), and Final Evaluation (C_6).

The SAW computation is executed in two sequential mathematical stages to ensure an objective, transparent, and structured assessment of student technical competencies:

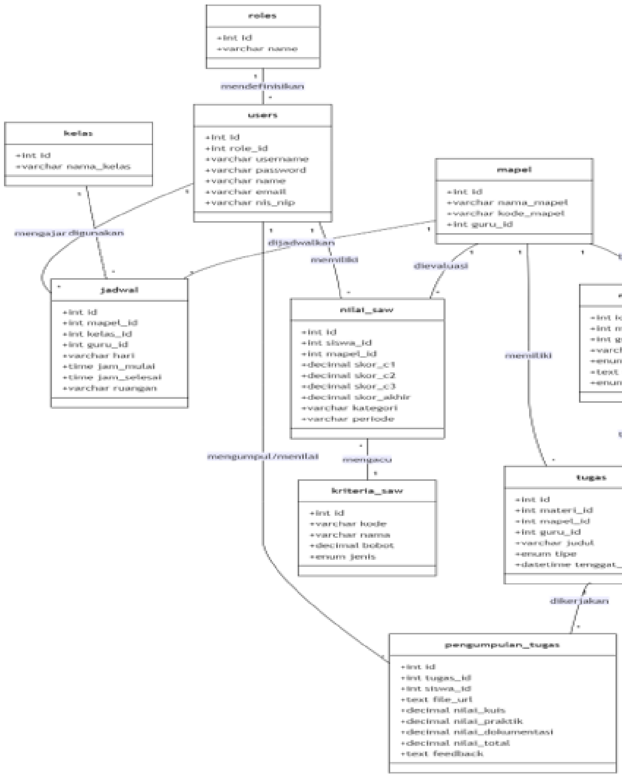

Figure 3. Class Diagram of the Evaluation System Database

a Decision Matrix Normalization

First, the system constructs a decision matrix from the raw student scores. Since all six criteria are classified as "benefit" attributes (where a higher score indicates better performance), the system applies a max-benefit normalization process to scale all raw scores into a comparable range of 0 to 1. The normalization formula is defined as:

$$R_{ij} = \frac{X_{ij}}{\max_i(X_{ij})} \tag{1}$$

Where:

- R_{ij} = the normalized rating of student i on criterion j.
- X_{ij} = the raw score of student i on criterion j.
- $\max_i(X_{ij})$ = the maximum raw score achieved across all students for criterion j (standardized to 100 in this system's grading scale).

b Preference Value Calculation

Following normalization, the system calculates the final preference value (V_i) for each student by performing a weighted summation of the normalized scores. This is expressed mathematically as:

$$V_i = \sum_{j=1}^{n} W_j \cdot R_{ij} \tag{2}$$

Where:

- V_i = the final preference score for student i.
- W_j = the predetermined weight of criterion j (e.g., 0.15 for Quiz, 0.25 for Final Evaluation, ensuring $\sum W_j = 1$).
- R_{ij} = the normalized score of student i on criterion j.
- n = the total number of criteria ($n = 6$).

To present the final output in a familiar 0–100 grading scale, the resulting V_i is inherently scaled to match the maximum raw score baseline. This mathematical approach yields a highly accountable competency score. The final output is then automatically mapped to a predefined classification range, providing a clear, real-time overview of whether a student is "Highly Competent" (85–100), "Competent" (70–84), "Fairly Competent"

(55–69), or requires “Remedial” intervention (< 55).

2.5 Algorithm Logic Flowchart

The logical sequence of the automated assessment process is clearly depicted in the algorithm logic flowchart. It begins with the extraction of raw scores from the student task database for all six criteria defined in the system. The flowchart illustrates how the system checks for data completeness before proceeding to the mathematical normalization stage [19, 20].

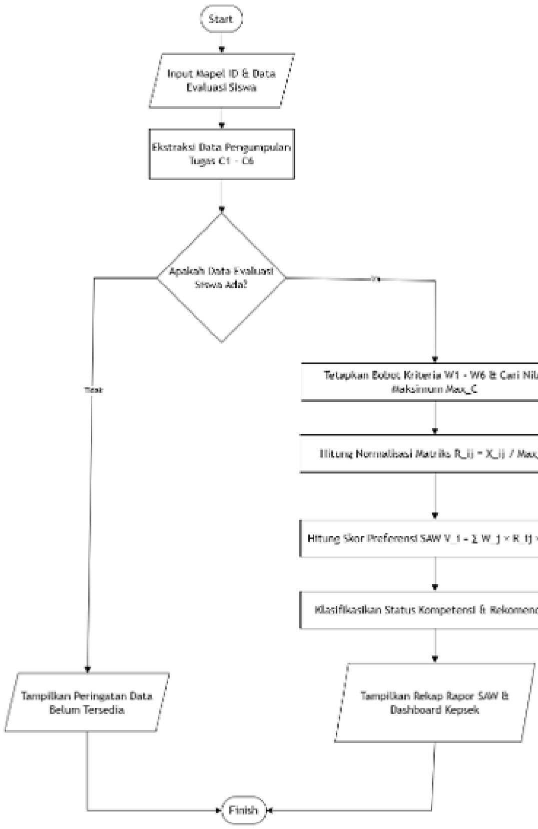

Figure 4. Flowchart of the SAW Algorithm Logic

After the normalization is complete, predetermined weights are applied to calculate the final preference score for each student. This flowchart serves as the primary technical guide for implementing the SAW logic within the system’s backend controller. It ensures that the automated grading process is executed consistently every time a teacher triggers the evaluation module.

2.6 Experimental Setup and Functional Testing

The platform is implemented using the PHP programming language and the CodeIgniter framework, adhering to the Model-View-Controller (MVC) architectural pattern. It utilizes a MySQL relational database to securely store student profiles, learning materials, and detailed assessment records.

To verify the system’s external behavior against predefined user requirements, functional testing is conducted via the Black Box testing method. Specifically, the Equivalence Partitioning technique is applied to systematically test various input scenarios, such as form submissions, authentication credentials, and SAW calculation triggers, without needing to examine the internal code structure.

Mathematically, the Equivalence Partitioning technique divides the total input domain D of a given system function into mutually exclusive subsets (equivalence classes) E_k, such that:

$$D = \bigcup_{k=1}^{m} E_k \quad \text{and} \quad E_a \cap E_b = \emptyset, \quad \forall a \neq b \tag{3}$$

In this experimental setup, the input domain is partitioned into two primary categories:

1. **Valid Equivalence Class (E_{valid}):** Any test case (e.g., a student score between 0 and 100) is expected to be processed successfully, resulting in a valid system state (e.g., data saved and preference score calculated).
2. **Invalid Equivalence Class (E_{invalid}):** Any test case (e.g., a score < 0, > 100, or non-numeric characters)

is expected to be intercepted by the system, triggering an error-handling state (e.g., displaying a validation warning) without crashing the application.

By selecting at least one representative test case from each equivalence class, this comprehensive testing phase ensures that all system modules—from user authentication to the core SAW evaluation engine—perform reliably and handle edge cases gracefully. The resulting feedback and pass/fail metrics from this testing phase are systematically documented and used to iteratively refine the user interface, ensuring optimal engagement and usability for both teachers and students.

3 RESULTS AND DISCUSSION

3.1 System Interface and User Roles

The development phase successfully produced a centralized web-based e-learning platform specifically designed for the automotive curriculum at SMK Cahaya Otomotif 2. The Admin Dashboard acts as the primary command center, providing visual statistics on the total number of students, teachers, and active automotive subjects registered in the system. For academic delivery, the Teacher Interface allows for structured classroom management where instructors can upload PDF modules, video tutorials, and create interactive quizzes or practice rubrics. Students interact with the system through a dedicated Learning Portal, enabling them to download automotive materials and view their skill progress with full transparency. Crucially, the Principal Dashboard offers real-time analytical monitoring of student achievement across various competency levels. This multi-role architecture directly addresses the lack of integrated digital infrastructure identified in previous studies regarding traditional vocational settings.

3.2 Computational Validation of the SAW Algorithm

The primary contribution of this system is the automated evaluation engine powered by the Simple Additive Weighting (SAW) algorithm [16–18]. To ensure accuracy, the system was validated using operational data from students. The evaluation utilized six criteria with specific weights:

Table 1. SAW Evaluation Criteria

Code	Evaluation Criteria	Weight (W)
C_1	Quiz or Exercise Score	15%
C_2	Forum Discussion Participation	10%
C_3	Practical Task Performance	20%
C_4	Attendance	5%
C_5	Mid-term Exam (UTS)	25%
C_6	Final Evaluation (UAS)	25%
Total		**100%**

Table 1 outlines the six distinct evaluation criteria and their respective weights (W_j) established for the automated assessment system. The determination of these specific weights was derived through structured interviews with vocational teachers and school management at SMK Cahaya Otomotif 2, ensuring the evaluation model accurately reflects both academic standards and industry readiness requirements.

The weight distribution is strategically designed to balance theoretical knowledge with hands-on technical proficiency, which is the core mandate of vocational education. The highest weights are assigned to the Mid-term Exam (C_5: 25%) and Final Evaluation (C_6: 25%), as these serve as comprehensive, cumulative measures of a student's overall mastery of the automotive curriculum. Practical Task Performance (C_3) is also heavily weighted at 20%, directly emphasizing the system's focus on evaluating tangible, hands-on workshop competencies, such as vehicle maintenance and repair documentation.

The remaining criteria support continuous learning and foundational discipline. Quiz or Exercise Scores (C_1: 15%) and Forum Discussion Participation (C_2: 10%) are utilized to measure consistent engagement, formative understanding, and collaborative learning throughout the semester. Attendance (C_4: 5%) acts as a foundational baseline, rewarding student discipline and commitment to the learning process without disproportionately skewing the final technical competency score.

From a mathematical perspective, this weight distribution strictly satisfies the fundamental constraint of the Simple Additive Weighting (SAW) algorithm, where the sum of all criterion weights must equal one (or 100%):

$$\sum_{j=1}^{6} W_j = 0.15 + 0.10 + 0.20 + 0.05 + 0.25 + 0.25 = 1.00 \tag{4}$$

This ensures that the subsequent normalization and preference value calculations (V_i) are mathematically sound,

proportionally accurate, and capable of producing a fair, standardized competency score for every student.
Once the final preference value (V_i) is computed for each student using the SAW algorithm, the numerical output must be translated into an actionable pedagogical category. To achieve this, the system implements a rule-based classification engine that maps the continuous score range (0–100) into four distinct competency tiers. These thresholds are established in accordance with standard vocational education assessment guidelines at SMK Cahaya Otomotif 2, ensuring that the automated output aligns with the school's academic grading policies and industry competency benchmarks. Table 2 details the specific score ranges, the corresponding competence categories, and the targeted instructional recommendations generated by the system for each tier.

Table 2. Competency Classification

Score Range	**Competence Category**	**Recommendation**
85 – 100	Sangat Kompeten (Highly Competent)	Maintain performance! Advanced enrichment.
70 – 84	Kompeten (Competent)	Good mastery, improve practical precision.
55 – 69	Cukup Kompeten (Fairly Competent)	Need to deepen practical and forum aspects.
< 55	Perlu Remedial (Needs Remedial)	Mandatory special guidance & consultation.

As outlined in Table 2, the classification system does not merely assign a static grade; it dynamically generates targeted pedagogical recommendations based on the student's computed score. For students falling into the "Highly Competent" (85–100) and "Competent" (70–84) categories, the system recommends advanced enrichment and practical refinement, effectively preparing them for industrial internships (PKL) or higher-level technical certifications. Conversely, students classified as "Fairly Competent" (55–69) receive automated prompts to focus on specific developmental areas, such as deepening their practical workshop skills or increasing their forum engagement. Crucially, students scoring below 55 are immediately flagged for "Needs Remedial" status. This triggers an automated alert to the vocational teacher, mandating special guidance and consultation to prevent competency gaps from widening. By coupling quantitative SAW scores with qualitative, action-oriented recommendations, the system transforms raw evaluation data into a proactive, decision-support tool for personalized vocational education.
To empirically validate the computational accuracy of the proposed evaluation engine, a step-by-step calculation simulation was conducted using real operational data from a sample student at SMK Cahaya Otomotif 2. Table 3 details the execution of the SAW algorithm for this specific case. The process initiates with the extraction of the student's raw scores (X_j) across the six defined criteria. Because the maximum achievable score for each criterion in the academic grading scale is 100, the normalization value (R_j) is derived by dividing each raw score by the maximum value (100). Following normalization, the system computes the weighted contribution of each criterion. To ensure the final output remains on a standardized 0–100 scale, the weighted calculation is computed as $W_j \times R_j \times 100$.

Table 3. Calculation Simulation of SAW Algorithm

Criterion	**Raw Score (X_j)**	**Weight (W_j)**	**Normalization (R_j)**	**Final Score (V_j)**
C_1 (Quiz)	100.0	0.15	1.00	15.00
C_2 (Forum)	85.0	0.10	0.85	8.50
C_3 (Practice)	85.0	0.20	0.85	17.00
C_4 (Attendance)	100.0	0.05	1.00	5.00
C_5 (UTS)	95.0	0.25	0.95	23.75
C_6 (UAS)	90.0	0.25	0.90	22.50
Total Preference (V_i)				**91.75**

As demonstrated in Table 3, the summation of all weighted criteria yields a final preference value (V_i) of 91.75 for the sample student. This computed value perfectly matches the output generated by the system's backend database, confirming zero deviation between the theoretical algorithm and the programmatic execution. Based on the classification rules established in Table 2, a preference score of 91.75 falls within the 85–100 range, automatically categorizing the student as "Sangat Kompeten" (Highly Competent). This validation step is critical as it proves that the PHP-based controller accurately translates the mathematical logic of the SAW algorithm into real-time skill measurement. Consequently, the system guarantees that the automated grading process is transparent, mathematically sound, and entirely free from manual calculation errors, thereby providing a highly accountable competency report for both students and school management.

3.3 Summary of Black Box Testing Results

To ensure the operational reliability and functional correctness of the developed e-learning platform, a rigorous testing phase was conducted using the Black Box testing methodology. This approach evaluates the system's external behavior and functional capabilities without examining the internal code structure, making it highly suitable for validating user-facing features against predefined requirements. Specifically, the Equivalence Partitioning technique was employed to systematically divide the input domains of each module into valid and invalid classes. This ensures that the system not only processes correct data efficiently but also gracefully handles and rejects erroneous inputs. The testing scenarios were meticulously designed to cover the critical operational paths of the system, ranging from basic user authentication and content management to the core execution of the SAW evaluation algorithm. Table 4 presents the comprehensive summary of these testing scenarios, detailing the expected outcomes and the actual validation status for each primary feature.

Table 4. Summary of Black Box Testing Results

No	Main Feature	Testing Scenario	Expected Result	Status
1	Authentication	Input valid username and password	Redirect to appropriate Dashboard	Valid
2	User Management	Admin adds new teacher or student	Data saved and appears in list	Valid
3	Content Management	Teacher uploads PDF or Video module	Content visible in student portal	Valid
4	Task Submission	Student uploads practice documentation	File saved and status changed to "Terkumpul"	Valid
5	SAW Evaluation	Teacher inputs scores C_1–C_6	Final score (V_i) generated automatically	Valid
6	Monitoring Report	Principal prints report	System generates graph and physical report	Valid

As summarized in Table 4, all six primary features of the e-learning system achieved a "Valid" status, indicating a 100% pass rate for the tested scenarios and demonstrating the absence of logical errors in data handling and process execution. Notably, the system successfully executed its most critical function—the automated generation of the final preference score (V_i) based on the C_1 to C_6 criteria inputs—seamlessly integrating the SAW algorithm into the backend controller. Furthermore, the equivalence partitioning tests confirmed that the system's validation mechanisms are highly robust; it effectively intercepted and rejected invalid inputs, such as incomplete rubric submissions, non-numeric score entries, or incorrect login credentials, thereby ensuring strict data integrity. These empirical results prove that the platform's functional performance is on par with established web frameworks utilized in similar academic institutions. Ultimately, this successful testing phase confirms that the system is stable, secure, and fully prepared for full-scale deployment and institutional adoption at SMK Cahaya Otomotif 2.

3.4 Discussion of Practical Implications

The implementation of the proposed e-learning system effectively resolves the critical "manual rubric" bottleneck previously identified in the operational workflow at SMK Cahaya Otomotif 2. By digitalizing practical assessments, the platform establishes a centralized, secure repository for essential technical documentation—such as vehicle repair photos and procedural videos—that were previously fragmented and difficult to track.

Pedagogically, the integration of the SAW algorithm introduces a highly objective and transparent grading mechanism. This transparency directly enhances student motivation by providing immediate, data-driven feedback regarding their technical skill standing, thereby fostering a culture of continuous self-improvement and accountability. From an administrative perspective, the system's real-time monitoring capabilities empower school management and vocational teachers to identify and intervene with struggling students proactively. This shifts the evaluation paradigm from a reactive, end-of-semester review to a continuous, formative assessment model.

Ultimately, this proactive approach significantly supports the development of critical thinking and learning independence, aligning seamlessly with the competency-based standards of modern vocational education. Furthermore, the modular architecture of the developed system ensures high scalability; the evaluation framework can be readily adapted and expanded to assess various other technical competencies within the broader automotive curriculum, offering a sustainable and replicable digital transformation model for vocational institutions.

4 CONCLUSION

This research has successfully developed web-based e-learning software using the PHP programming language and the CodeIgniter framework, effectively digitalizing the entire skill evaluation process at SMK Cahaya Otomotif 2. The implementation of the Simple Additive Weighting (SAW) algorithm within this system proved highly effective for generating objective student skill assessments through the weighting of six evaluation criteria, which include quizzes, discussion forums, practical tasks, attendance, and mid-term as well as final exams. Through operational testing, validation results of manual calculations against student data such as a sample student scoring 91.75, demonstrate that the system's computations are perfectly aligned with SAW weighted summation theory. The system also successfully provides transparency of learning outcomes for students in the form of competency reports and assists the Principal in monitoring the skill development of all students in real-time through an informative graphical dashboard. Finally, based on the testing results using the Black Box method, all primary system features are declared functional and valid, consistent with the previously established user requirement specifications.

For further system development to perfect the quality of academic evaluation services, it is suggested that a mobile application interface be developed so that students can have greater flexibility in accessing learning materials and uploading practical documentation directly from their devices. Furthermore, the addition of a QR Code scanner feature in the assignment module could be considered to accelerate the data recording of automotive workshop tools and materials used by students during practical sessions. Future research could also involve comparative studies with other decision-support algorithms, such as AHP or TOPSIS, to enhance accuracy in the student competency classification process. Integrating the system through API interfaces with school master databases or DAPODIK is also highly recommended to ensure broader and automated synchronization of student identity data. As a final step, regular updates to server security protocols and the implementation of stronger database encryption are required to ensure the confidentiality of student grade data and practical portfolio documents.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to SMK Cahaya Otomotif 2 as the research object for providing the facilities, data, and cooperation necessary to conduct this study. Special thanks are also extended to the vocational teachers and students who participated in the interviews and system testing phases.

DECLARATIONS

Author Contributions:

Abi Nanda Septiansyah: Conceptualization, Methodology, Software, Writing–original draft.
Anita Ratnasari: Supervision, Methodology, Writing–review & editing.

Funding:

The authors received no financial support for the research, authorship, and/or publication of this article.

Conflicts of Interest:

The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability:

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Use Statement:

During the preparation of this work, the authors used Gemini in order to improve the language and readability of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the final content of the published article.

Additional Information:

No additional information is available for this paper.

REFERENCES

[1] L. Lionie, H. Septanto, dan E. Wahyuningsih, "PELUANG DAN TANTANGAN ELEARNING BAGI MAHASISWA DAN DOSEN DI ERA PANDEMI COVID 19," *J. Tera*, vol. 1, no. 1, hlm. 109–122, Mei 2021, doi: 10.59832/jt.v1i1.25.

[2] S. Hadi, J. Sapri, dan E. Risdianto, "Development of Interactive Learning Media on Light Vehicle Engine System Based on Classpoint to Improve Student Learning Achievement (A Study on Light Vehicle Engine System Components for Grade XI Students at SMK Negeri 3 Seluma)," *JENTIK J. Pendidik. Teknol. Inf. Dan Komun.*, vol. 4, no. 1, hlm. 31–49, Jun. 2025, doi: 10.58723/jentik.v4i1.449.

[3] H. Firdaus, S. Syafrizal, dan L. Nulhakim, "The Effectiveness of Electronic Teaching Materials in Vocational High Schools on Students' Independent Learning Responses," *ICoCSE Proc.*, vol. 1, no. 0, hlm. 111–116, Des. 2024.

[4] H. Pratomo, N. C. Sitompul, dan N. Nurjati, "Pengembangan E-Learning untuk meningkatkan Pembelajaran Elektrikal Kendaraan Ringan di SMK Negeri 1 Sidoarjo," *J. Educ. Res.*, vol. 6, no. 1, hlm. 139–147,

Feb. 2025, doi: 10.37985/jer.v6i1.2278.

[5] B. Ariwibowo, F. Z. Bahtiar, A. Atika, dan J.-B. L. Consuelo, "Development of a virtual reality-based learning model for automotive competence," *J. Taman Vokasi*, vol. 12, no. 2, hlm. 189–200, Des. 2024, doi: 10.30738/jtvok.v12i2.18130.

[6] K. Y. Priatama dan M. Martubi, "STUDI PELAKSANAAN E-LEARNING PADA MATA PELAJARAN PEKERJAAN DASAR TEKNIK OTOMOTIF DI JURUSAN MANAJEMEN DAN PERAWATAN OTOMOTIF SMK NEGERI 2 KLATEN," *J. Pendidik. Vokasi Otomotif*, vol. 5, no. 2, hlm. 27–39, Jun. 2023, doi: 10.21831/jpvo.v5i2.51876.

[7] B. Basori, S. Sajidan, M. Akhyar, dan W. Wiranto, "Analysis Of Vocational Students' Critical Thinking Skills Using The OER-Assisted Blended Learning," *J. Innov. Educ. Cult. Res.*, vol. 4, no. 2, hlm. 264–270, Apr. 2023, doi: 10.46843/jiecr.v4i2.566.

[8] I. F. Fariz, S. Hidayat, dan I. Rusdiyani, "Developing Google Sites-Based E-Modules to Enhance Teachers' ICT Competence at Al Husna Foundation," *AL-ISHLAH J. Pendidik.*, vol. 17, no. 3, hlm. 5568–5579, Okt. 2025, doi: 10.35445/alishlah.v17i3.7275.

[9] A. G. Kamal dan T. Wahyono, "RANCANG BANGUN APLIKASI E-LEARNING PERGURUAN TINGGI DENGAN PEMODELAN BERBASIS UNIFIED MODELING LANGUAGE," *IT-Explore J. Penerapan Teknol. Inf. Dan Komun.*, vol. 3, no. 3, hlm. 329–347, Okt. 2024, doi: 10.24246/itexplore.v3i3.2024.pp329-347.

[10] Rabi'ah, Y. Hadiwinarso, dan R. Jannah, "Gamification and Interactive Learning: Enhancing Students Engagement and Proficiency Outcomes," *Entita J. Pendidik. Ilmu Pengetah. Sos. Dan Ilmu-Ilmu Sos.*, hlm. 909–920, Mei 2025, doi: 10.19105/ejpis.v1i.19133.

[11] M. A. Setiawan, E. Darmanto, dan B. Basuki, "PENGEMBANGAN SISTEM INFORMASI E-LEARNING BERBASIS PHP PADA SMP NEGERI 1 MAYONG," *BHAKTI NAGORI J. Pengabdi. Kpd. Masy.*, vol. 5, no. 2, hlm. 864–875, Des. 2025, doi: 10.36378/bhakti_nagori.v5i2.5055.

[12] M. Yusril, S. Paembonan, dan H. Abduh, "RANCANG BANGUN SISTEM E-LEARNING BERBASIS WEBSITE MENGGUNAKAN FRAMEWORK CODEIGNITER DI SMAN 9 LUWU," *J. Inform. Dan Tek. Elektro Terap.*, vol. 12, no. 3, Agu. 2024, doi: 10.23960/jitet.v12i3.5136.

[13] R. Iskandar, "Assessing the Digital Literacy Profile of Promising Automotive Engineering Teacher Candidates," *J. Educ. Teach. JET*, vol. 5, no. 1, hlm. 60–69, Jan. 2024, doi: 10.51454/jet.v5i1.331.

[14] N. P. T. Prakisya dkk., "PEMANFAATAN ALGORITMA SAW PADA SISTEM PENUNJANG KEPUTUSAN UNTUK PENENTUAN STRATEGI BELAJAR PADA ADAPTIVE LEARNING," *JST J. Sains Dan Teknol.*, vol. 11, no. 2, hlm. 351–361, Agu. 2022, doi: 10.23887/jstundiksha.v11i2.45319.

[15] R. Ardhani, M. M. Munir, dan A. M. Dawis, "PENERAPAN METODE WATERFALL DALAM PERANCANGAN SISTEM INFORMASI E-LEARNING BERBASIS WEB PADA MADRASAH TSANAWIYAH (MTS) AL-WUSHO RUMAH SETIA," *J. Innov. Future Technol.*, vol. 5, no. 2, hlm. 64–73, Agu. 2023, doi: 10.47080/iftech.v5i2.2754.

[16] S. S. Sitanggang and A. S. Manalu, "Implementation of Additive Weighting in Providing in Receiving Bidik Misi Scholarships at the Politeknik Bisnis Indonesia," *J. Comput. Networks, Archit. High Perform. Comput.*, vol. 2, no. 1, pp. 171–179, 2020, doi: 10.47709/cnahpc.v2i1.949.

[17] A. R. Selvada, Sumijan, and Yuhandri, "Penerapan Metode Simple Additive Weighting dalam Sistem Pendukung Keputusan Pemilihan Jurusan (Studi Kasus di SMK Negeri 1 Kota Solok)," *Innov. J. Soc. Sci. Res.*, vol. 3, no. 4, pp. 9180–9191, 2023.

[18] A. Amintas, V. Atina, and A. I. Pradana, "Sistem Pendukung Keputusan Mutasi Pegawai Menggunakan Metode Simple Additive Weighting pada Sekretariat Daerah Kabupaten Sragen," *JATISI (Jurnal Tek. Inform. dan Sist. Informasi)*, vol. 12, no. 2, pp. 64–74, 2025, doi: 10.35957/jatisi.v12i2.10546.

[19] M. Multazam and E. Y. Saniyah, "Development and Implementation of Woven Bamboo Handicraft Online Shop in Loyok Village, Lombok, Indonesia," *J. Techno Nusa Mandiri*, vol. 17, no. 2, pp. 123–130, 2020, doi: 10.33480/techno.v17i2.1638.

[20] Y. A. Rahman, T. Haryanti, and S. Informasi, "PERANCANGAN SISTEM INFORMASI INVENTORY

MONITORING BERBASIS WEB PADA PT PELINDO II CABANG," *J. Teknol. Inf. ESIT*, vol. 16, no. 1, pp. 1–8, 2020.