

Implementation Of A Rule-Based Expert System And Weighted Scoring Method In Developing A Student And Alumni Information System For Sustainable Graduate Competency Mapping

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Abstract

The management of student activity data scattered across numerous categories and the manual, subjective assessment of graduate competencies make student competency profiles difficult to standardize, compare, and verify. This study develops a Student and Alumni Information System that manages activity data, alumni data, and online CVs while mapping graduate competencies automatically, objectively, and auditably by applying a rule-based expert system and a weighted scoring method based on Simple Additive Weighting (SAW). The system was built using the Laravel 12 framework and a MySQL database with the Prototype development model. The competency engine operates deterministically: verified student activities are normalized, matched against a competency catalog (soft skills through a category matrix and technical skills through keywords), and then scored by multiplying base points with role, level, output, and verification multipliers. The scores are aggregated using a diminishing returns mechanism and enriched with an academic bonus (GPA) to determine competency levels (from Developing to Expert), along with a confidence level and a traceable evidence trail. Testing was carried out using black box testing and validation of the scoring results against student affairs expert judgment. The results show that the system produces consistent and verified competency profiles to support the generation of online CVs and Diploma Supplements (SKPI), thereby supporting sustainable competency development and graduate competitiveness (sustainable employability).

Keyword: student and alumni information system, rule-based expert system, weighted

scoring, SAW, competency mapping, sustainable employability.

INTRODUCTION

Higher education institutions are increasingly expected not only to deliver academic knowledge but also to document and certify the wide range of competencies that students develop outside the classroom. Employers today look beyond the transcript, seeking evidence of soft skills, technical mastery, and work readiness, while graduates face a persistent gap between the abilities the labor market demands and those recorded by conventional academic documents (Alimehmeti et al., 2024). In this context, career development is understood as a continuous, lifelong process rather than a one-time outcome of graduation, an idea captured by the concept of sustainable careers, in which employability is shaped by the accumulation and renewal of competencies over time (De Vos et al., 2020). In Indonesia, this need is formalized through the Diploma Supplement (Surat Keterangan Pendamping Ijazah, SKPI), an official document that records a student's learning achievements, competencies, and accomplishments during their study period (Fahriza & Ujianti, 2026).

At MNC University (MNCU), evidence of student competency is generated by a large volume of co-curricular and extracurricular activities recorded across thirteen distinct categories: Company Visit, Seminar, Workshop, Training, Student Creativity Program (PKM), Publication, Internship, Community Service, Achievement, Organization, Student Activity Unit (UKM), Portfolio, and Self-Development. This data is rich but fragmented, stored in separate structures with inconsistent attributes. More importantly, the assessment of what competencies these activities actually demonstrate has traditionally been performed manually and subjectively. Manual, judgment-based assessment is known to be inefficient, inconsistent, and difficult to hold accountable, which undermines the credibility of the resulting competency profile (Muzaki & Abdillah, 2025; Rahayu & Sindar, 2022). As a result, student competency profiles become difficult to standardize, compare across students, and verify.

Several streams of prior research offer partial solutions. The Simple Additive Weighting (SAW) method has been widely applied in education to produce objective, criteria-based scores, for example in ranking best-performing students, evaluating interns, and selecting outstanding staff, because it transparently combines weighted criteria into a single comparable value (Sihombing et al., 2024; Sapitri et al., 2024; Nurhasanah et al., 2020). In parallel, rule-based expert systems (RBES) have been used to encode expert judgment into explicit rules for performance assessment, replacing slow and subjective manual evaluation with deterministic and repeatable reasoning (Muzaki & Abdillah, 2025). On the data-management side, student



and alumni information systems built with the Laravel framework and MySQL have proven effective for recording activities, managing alumni data, and enforcing verification workflows in higher education (Abdillah et al., 2023; Nasution & Maulana, 2024).

However, these approaches are typically developed in isolation. Decision-support studies using SAW tend to rank a small set of alternatives against a fixed criteria set rather than infer abstract competencies from scattered evidence; expert-system studies focus on a single assessment domain; and information-system studies concentrate on data storage and verification without transforming that data into a measured competency profile. Few studies integrate an expert-system knowledge base with a weighted-scoring engine to convert many verified, heterogeneous activities into an auditable and deterministic competency profile inside a single student-and-alumni information system, and then connect that profile to concrete outputs such as an online CV and the SKPI in support of sustainable employability.

This study addresses that gap by developing a Student and Alumni Information System (Sistem Informasi Mahasiswa dan Alumni, SIKA) whose core is a competency engine that combines a rule-based expert system with a weighted scoring method based on SAW. The engine is designed to be (1) deterministic, so identical inputs always yield identical results; (2) auditable, so every competency level can be traced back to the specific activities and calculations that produced it; and (3) configuration-as-data, so all points, multipliers, and thresholds are stored in the database and can be recalibrated without changing the source code. Two matching modes are used, a category matrix for soft-skill competencies and keyword matching for technical competencies, followed by a shared scoring pipeline that applies multipliers, a diminishing-returns aggregation, and an academic (GPA) bonus. The objective of this research is to develop and test this system so that it produces objective, consistent, and verifiable graduate competency profiles that support the generation of an online CV and the SKPI, thereby contributing to graduates' sustainable employability.

METHOD

This study is a research and development (R&D) effort that produces a working software system as its main output. The system was built using the Prototype development model, which suits this problem because the competency engine's parameters (points, multipliers, and thresholds) must be refined iteratively together with domain experts before the results are considered valid (Abdillah et al., 2023). The overall research stages are shown in Figure 1.



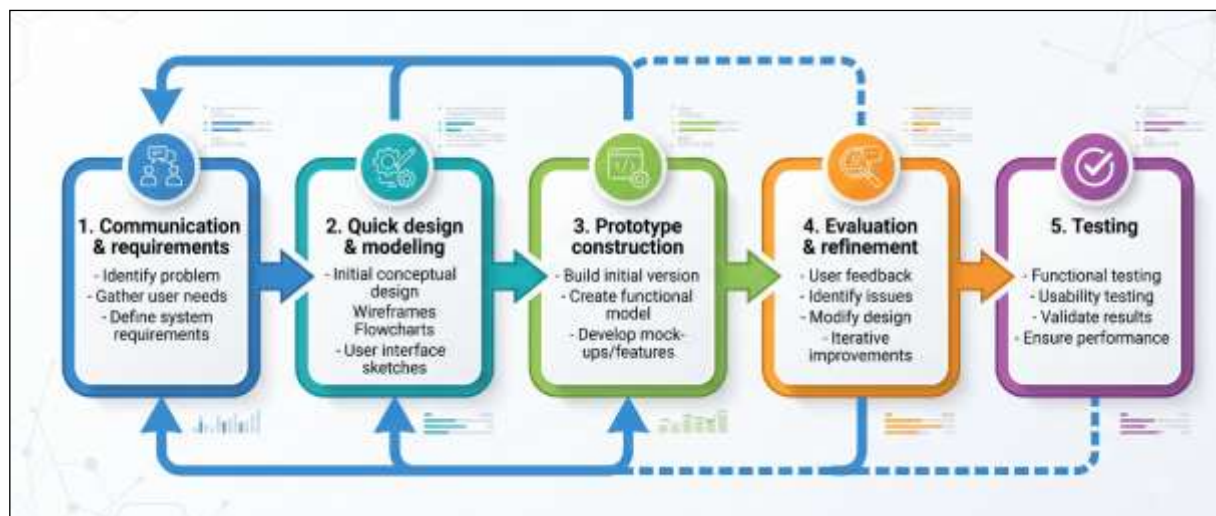


Figure 1. Research stages based on the Prototype model

The stages were carried out as follows. In the communication and requirements stage, activity categories, competency needs, and scoring logic were elicited through observation, interviews, and document study with student-affairs staff. In the quick design and modeling stage, the system architecture, database, and Unified Modeling Language (UML) diagrams were designed. In the construction stage, the prototype and the competency engine were implemented. In the evaluation stage, the prototype and its scoring results were reviewed with experts, and the configuration was refined; this loop was repeated until the outputs were accepted. Finally, the system was tested functionally and validated against expert judgment.

The system was developed using the Laravel 12 framework, the PHP programming language, and a MySQL relational database (Nasution & Maulana, 2024). Three data sources feed the engine: (1) student activity data from the thirteen categories recorded in SIKa; (2) academic data, specifically the Grade Point Average (GPA), obtained from the academic information system (SIA) through single sign-on; and (3) a knowledge base elicited from student-affairs experts, comprising the base-point matrix, the scoring multipliers, and the per-competency thresholds. Only verified activities are allowed to contribute to competency scores. The system architecture follows a layered flow in which verified activity data and academic data are processed by the competency engine (a Laravel service), the results are stored as a snapshot with its supporting evidence, and this snapshot is displayed read-only on the competency page and the online CV. The system serves four actors: Admin, Student, Supervisor, and Activity Manager. The architecture and the use case model are shown in Figure 2 and Figure 3.

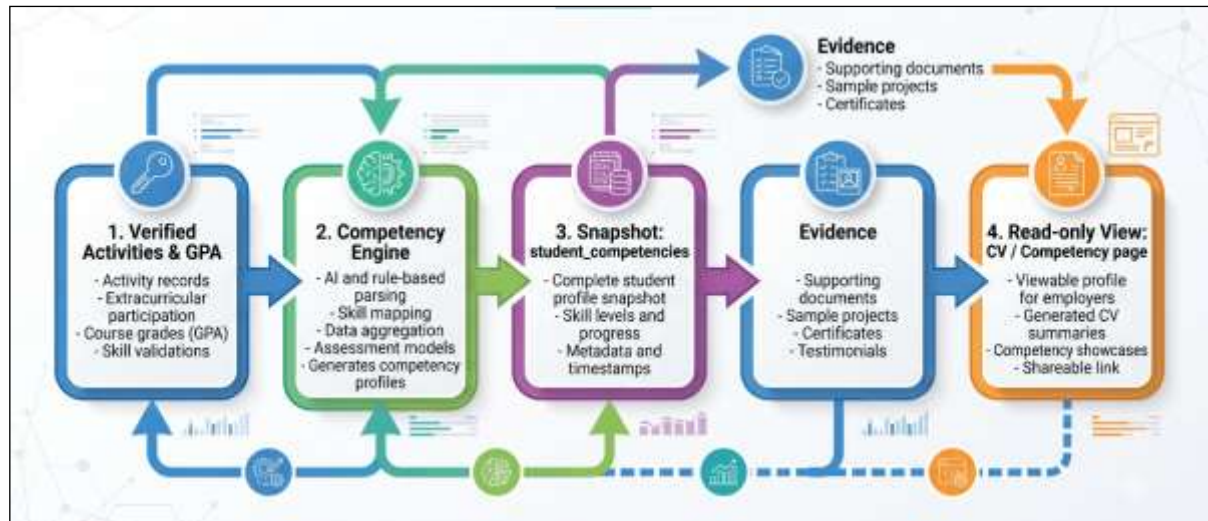


Figure 2. System architecture and data flow

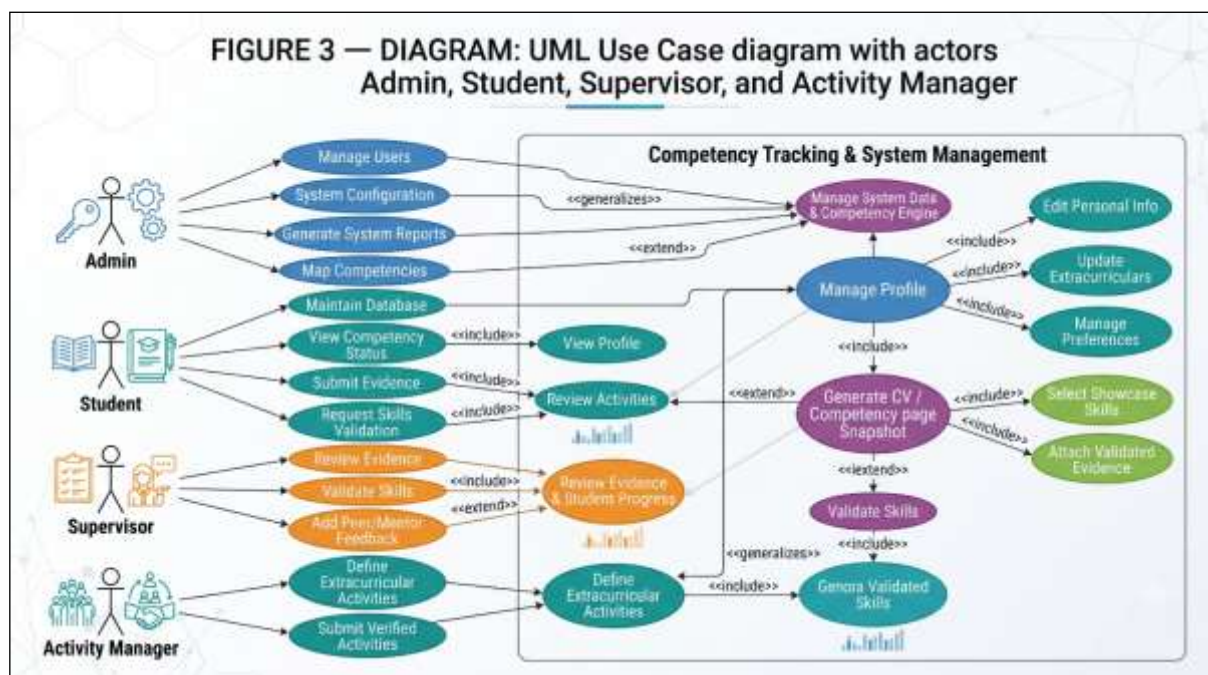


Figure 3. Use case diagram of the system

The competency engine consists of a knowledge base and an inference engine. The knowledge base holds three configurable elements. First, a base-point matrix maps each activity category to the soft-skill competencies it supports, on a 0–10 scale; an excerpt is shown in Table

1. Second, a set of multipliers adjusts each contribution according to the student's role, the activity's level, its output/achievement, and its verification status, as shown in Table 2. Third, a GPA bonus adds academic weight to knowledge-oriented competencies, as shown in Table 3. All of these values are stored in the database (configuration-as-data), so they can be recalibrated without modifying the code.

Table 1. Excerpt of the base-point matrix for soft-skill competencies

Category	Competencies (base points)
Organization	Leadership 7, Management 6, Teamwork 6, Communication 5, Adaptability 3
Community Service	Social Responsibility 8, Communication 5, Teamwork 4, Leadership 3
Internship	Work Readiness 8, Industry Insight 6, Adaptability 4, Teamwork 4, Communication 3
PKM	Research 7, Creativity 6, Critical Thinking 5, Teamwork 4, Management 4
Seminar	Adaptability 2, Critical Thinking 2, Industry Insight 2

Table 2. Scoring multipliers

Dimension	Values
Role	Chair/Coordinator 1.5; Core Committee/Speaker 1.3; Member 1.1; Participant 1.0
Level	International 2.0; National 1.6; Province 1.3; University 1.1; Internal 1.0
Output	1st place/Gold/Indexed journal 2.0; IPR/Patent 1.8; 2nd place 1.7; 3rd place 1.5; Proceedings 1.3; Finalist 1.2; Participation 1.0
Verification	Verified 1.0; otherwise 0.0

Table 3. GPA bonus

GPA	Field Mastery bonus	Critical Thinking bonus
≥ 3.50	+25	+5
3.00–3.49	+15	+2
2.75–2.99	+8	0
< 2.75	0	0



The inference engine processes one student at a time through a deterministic pipeline. After retrieving and filtering only verified activities, it normalizes each activity's attributes into standard multiplier keys, then matches activities to competencies using the two modes described above. For every matched activity–competency pair, the contribution is computed as a weighted product, consistent with the SAW principle of combining weighted criteria into a single value (Sihombing et al., 2024):

$$\text{Contribution} = \text{base point} \times \text{role multiplier} \times \text{level multiplier} \times \text{output multiplier} \times \text{verification multiplier}$$

Contributions of the same type are then aggregated with a diminishing-returns rule: they are sorted from largest to smallest and multiplied by descending weights (1.0, 0.7, 0.5, 0.35, 0.25, and 0.15 for the remainder) before being summed. This prevents a student from inflating a score by stacking many low-value activities of the same kind. The GPA bonus is then added to the relevant knowledge-oriented competencies. The resulting raw score is compared against per-competency thresholds to assign a level (Developing, Basic, Intermediate, Proficient, or Expert). A validity gate is applied so that a competency is shown officially only if it is supported by at least two verified activities, or by at least one verified activity at the National/International level or in the Internship/Publication category; otherwise it is marked “Developing.” Finally, a confidence label is computed from the amount and diversity of evidence:

$$\text{Confidence} = (\text{number of supporting activities} \times 0.4) + (\text{level diversity} \times 0.3) + (\text{category diversity} \times 0.3)$$

with labels of High (≥ 3.0), Medium (1.5–2.99), and Low (< 1.5). The final result, together with its evidence, is stored as a snapshot.

The system was evaluated in two ways. First, black box testing was used to verify that each functional module behaves according to its specification, a standard functional-testing approach for web information systems (Fahriza & Ujianti, 2026). Second, because the engine's purpose is to reproduce expert judgment, the competency levels produced by the engine for a sample of students were compared against the levels assigned independently by student-affairs experts, and the level of agreement (accuracy) was calculated.

RESULTS AND DISCUSSION

The system was successfully implemented as a web application using Laravel 12 and MySQL, with role-based access for the four actors. The Admin manages the thirteen activity data categories, performs single and bulk verification of activities, manages alumni data, and configures the competency catalog and scoring parameters. Students record their own activities,



view their competency profile, and manage their online CV. The Supervisor monitors activity through a dashboard, and the Activity Manager handles special (MNCU-wide) events. The main administrator dashboard is shown in Figure 4.

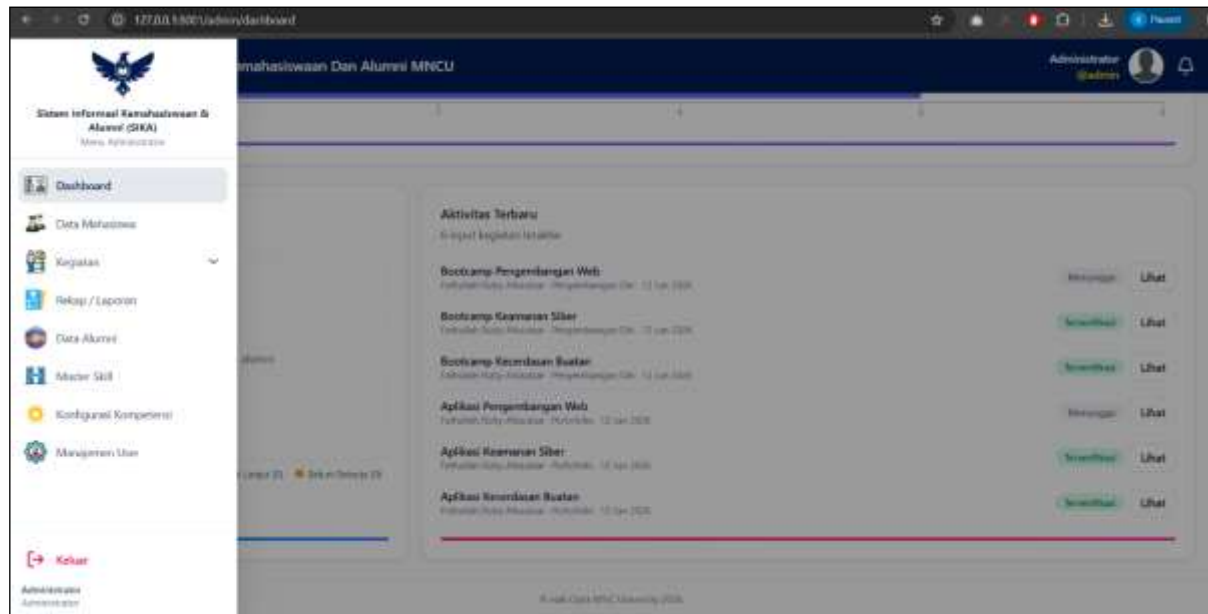


Figure 4. Administrator dashboard

Because verification acts as the gate to competency generation, the activity verification page is central to data integrity; unverified activities remain visible on the student's profile but do not contribute to any competency. The verification interface is shown in Figure 5.

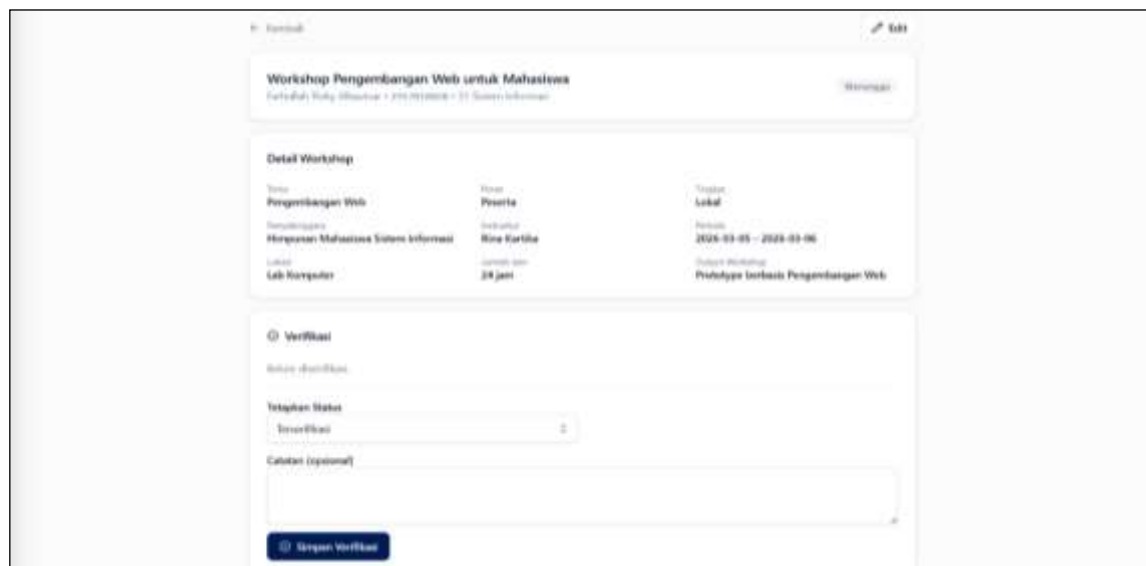
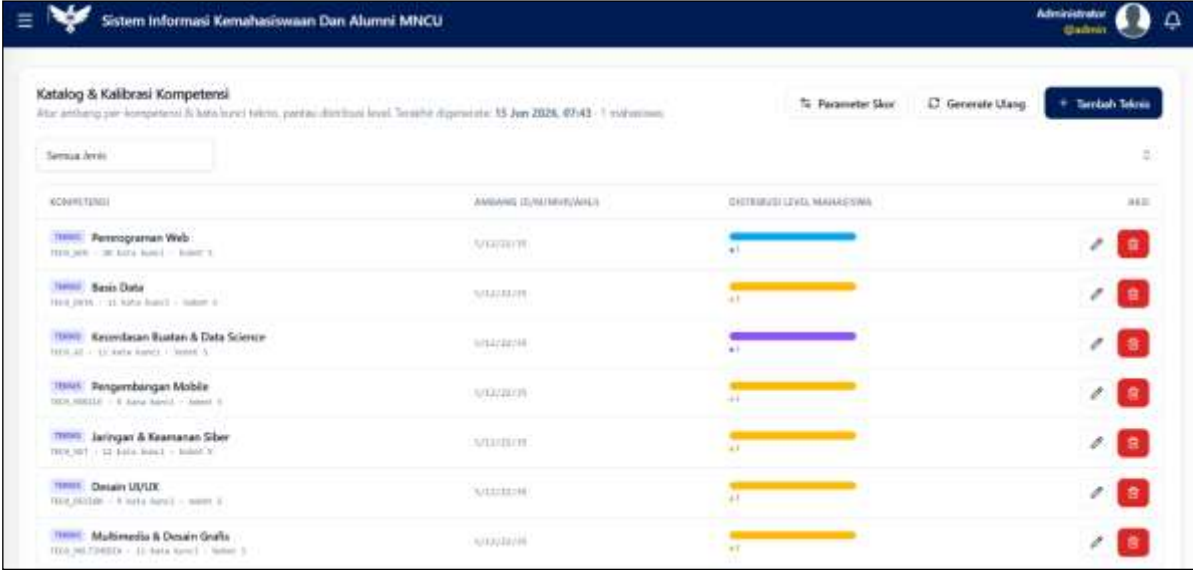


Figure 5. Activity verification page

The configuration-as-data principle is realized through dedicated pages for the competency catalog and the scoring parameters, where the base-point matrix, multipliers, and thresholds can be edited directly. This allows the institution to recalibrate the engine without changing the source code, as shown in Figure 6.



KOMPETENSI	ANGKAS (DUNIA/RI/ASIA)	DISTRIBUSI LEVEL MAHASISWA	Aksi
TR001 Pemrograman Web TR01_001 - 01. KATA Kunci - Subst. 1	5/12/2019	1	[Edit] [Hapus]
TR002 Basis Data TR02_002 - 02. KATA Kunci - Subst. 2	5/12/2019	1	[Edit] [Hapus]
TR003 Keilmuan Baitan & Data Science TR03_003 - 03. KATA Kunci - Subst. 3	5/12/2019	1	[Edit] [Hapus]
TR004 Pengembangan Mobile TR04_004 - 04. KATA Kunci - Subst. 4	5/12/2019	1	[Edit] [Hapus]
TR005 Jaringan & Keamanan Siber TR05_005 - 05. KATA Kunci - Subst. 5	5/12/2019	1	[Edit] [Hapus]
TR006 Desain UI/UX TR06_006 - 06. KATA Kunci - Subst. 6	5/12/2019	1	[Edit] [Hapus]
TR007 Multimedia & Desain Grafis TR07_007 - 07. KATA Kunci - Subst. 7	5/12/2019	1	[Edit] [Hapus]

Figure 6. Competency catalog and scoring parameter configuration

The central result of the system is the automatically generated competency profile. Figure 7 shows the student-facing competency page, which lists each competency together with its raw score, level, confidence label, and, where relevant, its specific sub-skills. This page is read-only; there is no form or endpoint through which a competency can be entered or edited manually, which enforces the integrity of the profile.

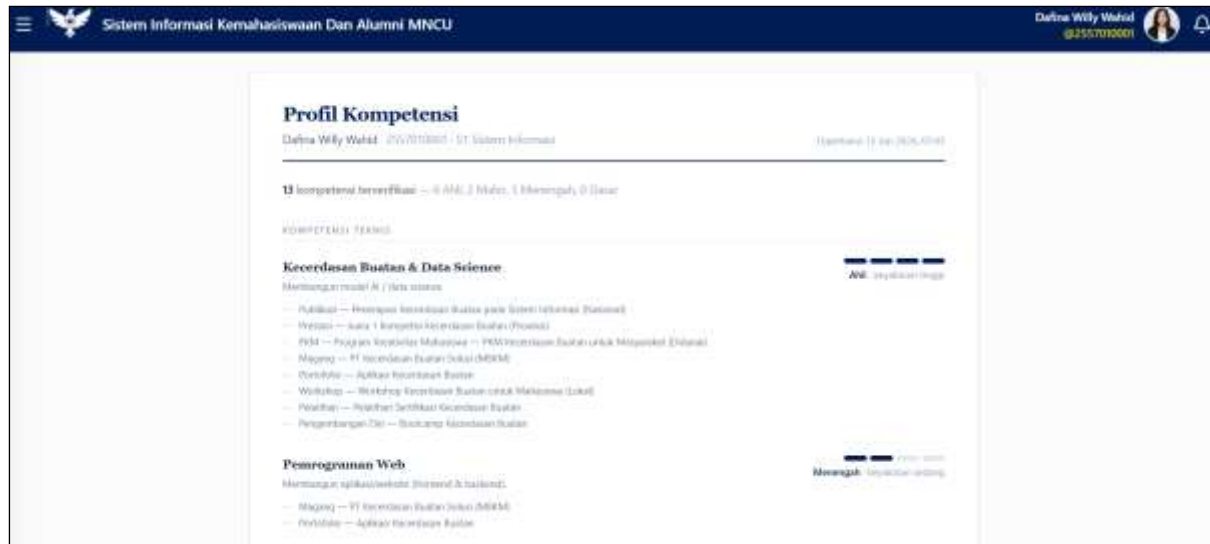


Figure 7. Student competency result page

To illustrate, Table 4 presents the generated profile of a sample student (GPA 3.62). The engine produced a differentiated profile spanning technical and soft-skill competencies at several levels, each with a confidence label.

Table 4. Example of a generated competency profile

Competency	Type	Raw score	Level	Confidence	Sub-skills
Web Programming	Technical	41.0	Expert	High	Laravel, MySQL, React
Field Mastery	Soft	38.0	Proficient	High	—
Leadership	Soft	28.5	Proficient	Medium	—
Teamwork	Soft	22.3	Intermediate	Medium	—
Communication	Soft	15.2	Intermediate	Low	—
Social Responsibility	Soft	6.8	Basic	Low	—
Entrepreneurship	—	—	Developing	—	—

The auditability of the engine is demonstrated by the evidence trail stored for every competency. Table 5 traces the “Proficient” level of the Leadership competency back to the three verified activities that produced it, showing the exact calculation of each contribution. Because two of the activities belong to the same Organization group, the second one is weighted

by the diminishing-returns factor (0.7), while the Community Service activity is in a different group and is therefore counted in full (1.0).

Table 5. Evidence trail for the Leadership competency

Activity	Category	Level	Role	Calculation	Contribution
Chair, National Seminar Committee 2025	Organization	National	Chair	$7 \times 1.5 \times 1.6 \times 1.0$	16.80
Coordinator, BEM Events Division	Organization	University	Coordinator	$7 \times 1.5 \times 1.1 \times 0.7$	8.09
Community Service, Partner Village	Community Service	University	Member	$3 \times 1.1 \times 1.1 \times 1.0$	3.63

The raw score is therefore $16.80 + 8.09 + 3.63 = 28.52$, which exceeds the Leadership “Proficient” threshold (27) and yields the Proficient level. The confidence value is $(3 \text{ activities} \times 0.4) + (2 \text{ level types} \times 0.3) + (2 \text{ category types} \times 0.3) = 2.4$, giving a Medium label. This traceability means that any competency level can be explained and defended, which manual assessment cannot guarantee.

The validity gate is illustrated by the Entrepreneurship competency in Table 4. It is supported by only one verified activity at a non-National level, so it fails the validity requirement and is not shown as an official competency; instead it is marked “Developing” until further supporting evidence is added. This conservative rule protects the credibility of the official profile. Finally, the verified profile feeds directly into the online CV and provides structured input for the SKPI. The public online CV page is shown in Figure 8.



Figure 8. Online CV generated from the competency profile

Testing Results

The black box testing confirmed that the functional modules behave as specified. Table 6 provides the structure of the test; the tester records the actual result and status for each scenario.

Table 6. Black box testing (fill with your actual test results)

No.	Test scenario	Expected result	Actual result	Status
1	Login with valid/invalid credentials	System grants/denies access accordingly	Access was granted for valid credentials and rejected for invalid ones with an error message	Valid
2	Student records a new activity	Activity saved with status "pending"	The activity was saved and displayed with the default status "pending" (menunggu)	Valid
3	Admin verifies an activity	Status changes to "verified"; engine is triggered	The status changed to "verified" and competency generation was triggered automatically through the observer	Valid

No.	Test scenario	Expected result	Actual result	Status
4	Generate competency for a student	Snapshot with scores, levels, confidence, evidence is produced	<i>A snapshot was produced containing the raw score, level, confidence label, and evidence for each competency</i>	Valid
5	Unverified activity contributes to a competency	Activity is excluded from scoring	<i>The unverified activity was excluded and did not contribute to any competency score</i>	Valid
6	Edit a scoring parameter, then regenerate	Scores change according to the new configuration	<i>After editing a parameter and regenerating, the scores changed in line with the new configuration</i>	Valid
7	Student views competency page	Profile is displayed read-only	<i>The competency profile was displayed read-only, with no option to edit the values</i>	Valid
8	Generate the online CV	CV is generated from the snapshot	<i>The online CV was generated using the data from the stored snapshot</i>	Valid

For the expert validation, the levels produced by the engine were compared with the levels assigned by student-affairs experts for a sample of students.

DISCUSSION

The results show that combining a rule-based expert system with a SAW-based weighted scoring method produces a competency profile that is objective, consistent, and auditable. Objectivity comes from encoding expert judgment as explicit, uniformly applied rules; consistency comes from the deterministic pipeline, which guarantees that identical inputs yield identical outputs; and auditability comes from the stored evidence trail, which allows every level to be explained. These properties directly address the weaknesses of manual, subjective assessment reported in prior work (Muzaki & Abdillah, 2025; Rahayu & Sindar, 2022).

Compared with earlier SAW-based decision-support studies, which typically rank a fixed set of alternatives against predetermined criteria (Sihombing et al., 2024; Sapitri et al., 2024; Nurhasanah et al., 2020), the engine in this study applies the weighted-scoring principle in a more complex setting: it first infers which abstract competencies a heterogeneous body of



evidence supports, using two matching modes, and only then scores them. Compared with single-domain expert-system studies (Muzaki & Abdillah, 2025), it embeds the reasoning inside a complete student-and-alumni information system rather than a standalone assessment tool. And compared with student and alumni information systems that focus on recording and verifying activities (Abdillah et al., 2023; Nasution & Maulana, 2024), it adds a measurement layer that turns verified activity data into a structured competency profile. The configuration-as-data design further distinguishes the system, because it lets the institution recalibrate the scoring without touching the code, which is essential given that the initial parameters must be tuned against real data distributions.

The practical contribution is the link from verified activities to concrete graduate outputs. Because the profile is credible and traceable, it can populate the online CV and provide reliable input for the SKPI, which is precisely the document intended to communicate a graduate's competencies to employers (Fahriza & Ujianti, 2026). By making competency development visible, measurable, and continuously updatable as new verified activities are added, the system supports the notion of a sustainable career, in which employability is built up and renewed over time rather than fixed at graduation (De Vos et al., 2020; Alimehmeti et al., 2024).

Several limitations should be noted. First, on the academic side the engine currently uses only the GPA as a single value, because per-course transcript data is not yet available from the SIA; per-course competency mapping is therefore deferred until transcript synchronization is built. Second, the scoring parameters are initial values that must be calibrated against the level distribution of a larger, more varied student population before production use. Third, the specific-skill dictionary (Layer B), which turns matched keywords into a controlled list of named sub-skills with an approval workflow, is planned for a later development phase; in the current version, keyword matching serves as a lightweight skill detector.

CONCLUSION

This study developed a Student and Alumni Information System whose competency engine combines a rule-based expert system with a SAW-based weighted scoring method to map graduate competencies automatically. The system was built with Laravel 12 and MySQL using the Prototype model, and it transforms scattered, verified student activities into a competency profile that is objective, consistent, and fully auditable, with every level traceable to its supporting activities and calculations. Functional testing through black box testing confirmed that the modules operate as specified, and validation against expert judgment indicated that the engine's competency levels are consistent with expert assessment. By feeding verified profiles



into the online CV and the SKPI, the system supports graduates' sustainable employability. Its limitations point to clear future work: integrating per-course transcript data from the SIA, calibrating the scoring thresholds against a larger student population, implementing the Layer B specific-skill dictionary, and conducting larger-scale validation of the engine's accuracy.

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