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# Mapping Prerequisite Knowledge Gaps for Differentiated Instruction in Smart Building Training: A Quantitative Case Study at BBPVP Serang

Devia Rafika Putri[1,2*], Suhendar[1], Siswo Wardoyo[1]

[1]Technical and Vocational Education, Universitas Sultan Ageng Tirtayasa, Serang, Indonesia

[2]Balai Besar Pelatihan Vokasi dan Produktivitas (BBPVP) Serang, Serang, Indonesia

*Correspondence: e-mail: 7788260002@student.untirta.ac.id

**ABSTRACT**

Government vocational training admits entrants from diverse educational backgrounds but assesses them against common competency standards. This study mapped prerequisite knowledge gaps to inform differentiated instruction in the Installation of Smart Building Integration Systems program at BBPVP Serang. A descriptive quantitative case study combined administrative records of 90 trainees, program and assessment documents, and a supervised 40-item diagnostic test administered to one class (n = 15). Indicator gaps were calculated as 100 minus the percentage of correct responses, and the distribution of errors across trainees was examined. More than half of the trainees (55.6%) were not vocational high school graduates. Six of 12 indicators showed gaps of at least 25 percentage points, led by electrical measurement and dashboard visualization (33.3 points each). Electrical errors were dispersed across the class, whereas errors in server setup, account security, and dashboard visualization were concentrated among fewer trainees. These findings indicate that indicator-level gap percentages alone are insufficient for planning instructional support without considering the distribution of errors across trainees. Dispersed gaps suggest a need for class-wide reinforcement, while concentrated gaps may warrant targeted support under identical final competency standards. The findings are limited by the small single-class diagnostic sample and the measurement of knowledge rather than practical performance; the proposed differentiated instruction remains untested. The study contributes an indicator-level procedure linking diagnostic results to the sequence of integrated electrical–digital competency tasks.

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## 1. INTRODUCTION

Government vocational training must combine access for entrants with diverse backgrounds and assessment against common occupational standards. UNESCO's TVET strategy, OECD analysis and Indonesian vocational revitalization policy emphasize relevance, inclusion and responsiveness to technological change (OECD, 2023; Presiden Republik Indonesia, 2022; UNESCO, 2022). This challenge is visible in the official 200-lesson-period (JP; 45 minutes per JP) Installation of Smart Building Integration Systems program implemented at BBPVP Serang (Kementerian Ketenagakerjaan Republik Indonesia, 2025). For analytical mapping, the ten core units are grouped into 86 JP of electrical work and 106 JP of digital integration, plus eight JP of supporting skills; these are study-defined groupings of the official units, not separate official curriculum categories. The competency demonstration combines installation, testing, connected devices, cloud integration, floor-plan visualization and automation within a 240-minute practical assessment, so a weakness in measurement, wiring or server configuration may obstruct subsequent stages. Such integrated tasks reflect a broader shift toward hybrid technician skills driven by technological innovation (Lewis, 2025).

The official program requires a minimum age of 17 years, no color blindness, and at least a vocational high-school qualification in electrical, mechanical, electronics, informatics or automation engineering, or the science stream of general upper-secondary school; prior training and work experience are not required (Kementerian Ketenagakerjaan Republik Indonesia, 2025). Trainees follow synchronous online teaching and open-resource asynchronous tasks before face-to-face workshops, so their online scores are not equivalent to supervised individual diagnostic evidence. A competency test precedes on-the-job training (OJT), where trainees may encounter different equipment and workplace routines.

Diagnostic assessment becomes formative when evidence is used to adapt instructional decisions (Black & Wiliam, 2009). Cognitive diagnostic reasoning focuses on response patterns and the knowledge processes underlying performance rather than relying on total scores alone (Leighton & Gierl, 2007). In vocational project-based training, this perspective supports examining both indicator-level gap magnitudes and their distribution across trainees before assigning support within shared competency standards. In Indonesia, national learning-and-assessment guidance (Badan Standar Kurikulum dan Asessmen Pendidikan, 2022) emphasizes using assessment evidence to identify learning needs and adapt subsequent instruction in school settings. This policy context supports the diagnostic rationale while remaining distinct from BBPVP Serang's government training requirements.

Domain-specific prior knowledge is associated with subsequent learning, although effect sizes vary by context (Simonsmeier et al., 2022). Differentiated instruction adapts content, learning processes and interim products to learners' readiness while maintaining common intended outcome (Tomlinson, 2017). Systematic reviews report positive but context-dependent cognitive effects, with evidence drawn mainly from primary and secondary schooling (Deunk et al., 2018; Smale-Jacobse et al., 2019). Indonesian vocational-school research has documented practical challenges in differentiated teaching and assessment (Susanti et al., 2025), and digital differentiation using Moodle has been examined in informatics instruction (Kusnendar et al., 2025). Institutional digital-readiness measurement has also been studied in Indonesian

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vocational schools (A. Setiawan et al., 2025), whereas the present study examines participant-level prerequisite knowledge within a specific electrical–digital task sequence. Vocational education research identifies challenges in responding to heterogeneous learning needs (Compen et al., 2025, 2026; Hiruy & Melesse, 2022). Meanwhile, studies of vocational digital competence have relied largely on surveys and self-report measures (Barboutidis & Stiakakis, 2023; Mohamad et al., 2025), and smart-building research in vocational education has evaluated learning media such as an IoT-controlled solar-power (PLTS) trainer kit (Anam et al., 2023; Pujirianto & Haryanto, 2024). However, the literature reviewed provides limited evidence on how prerequisite knowledge gaps are distributed across individual trainees and aligned with the sequence of integrated electrical–digital tasks in smart building training. Addressing this gap, the present study combines indicator-level knowledge mapping, individual error-distribution analysis, and alignment with practical-task requirements to inform class-wide reinforcement and targeted support. Indonesian vocational studies have demonstrated diagnostic assessment for differentiated instruction (Wardhani, 2023), digital diagnostic assessment in SMK (Pradana et al., 2026) and project-based learning in basic electrical/electronics education (Akhyar et al., 2024).

The objective of this study is to map trainees' electrical and digital prerequisite-knowledge gaps and examine their implications for differentiated instructional planning in smart building integration training. Specifically, the study asks: (RQ1) what are trainees' electrical and digital prerequisite-knowledge profiles; (RQ2) how do program units, job sheets and practical assessment tasks relate to diagnostic indicators; (RQ3) which indicators show the largest gaps relative to perfect test scores, and how are errors distributed; and (RQ4) what instructional implications for differentiated learning can be derived from the identified knowledge gaps and error distribution patterns? The contribution lies in indicator-based mapping of learning needs and its link to competency tasks, as a basis for designing more specific instructional support.

## 2. METHODS

### 2.1. Design, Sources and Participants

This descriptive quantitative case study combined three sources: program documents (the official 2025 competency-based curriculum (Kementerian Ketenagakerjaan Republik Indonesia, 2025), local job sheets and a locally documented competency demonstration), administrative records for all 90 available 2026 trainees in Batches 1, 3, 4 and 5, and a supervised diagnostic assessment of 15 of 16 enrolled Batch 5 trainees. Batch 2 did not offer this program. The 90 records form a census of available administrative records, not a random sample of applicants; detailed diagnostic and background responses relate only to Batch 5. All 15 diagnostic participants were older than 18 years and provided individual written informed consent. The first author was employed as an instructor at BBPVP Serang but did not teach the participating Batch 5 class at the time of diagnostic administration; another instructor taught the class. Participation was voluntary, diagnostic results did not affect training completion or competency assessment decisions, and participant identities were coded. Answers were scored against a predetermined key.

### 2.2. Instruments and Administration

The instrument contained 13 profile questions on the printed form, 15 electrical multiple-choice items grouped into five indicators (B1–B5), 25 digital/integration items grouped into seven indicators (A1–A7), and ten four-point digital-confidence items (blueprint in Appendix A2). An explicit "I do not know yet" option was scored as zero.

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Digital indicators were linked to program tasks and selected DigComp 2.2 areas (Vuorikari et al., 2022). Two subject-relevant experts reviewed the instrument: an LSP P2 BBPVP Serang competency assessor who helped develop the Smart Building competency assessment materials (MUK), and a Smart Building subject-matter instructor. They examined item alignment, technical accuracy, language, distractors and answer keys. Revision recommendations were incorporated before administration, including corrections to electrical-measurement wording and digital-task terminology. Reported relevance ratings for the 40 knowledge items were 5/5 from both validators (Aiken's V = 1.00 per item; n = 2); these ratings provide initial content-relevance evidence (Aiken, 1985; Kane, 2013). A limited readability check with two program alumni examined instructions, wording and completion time; their responses were excluded from the analysis. The ten digital self-confidence statements were researcher-developed from the tasks in the program job sheets (e.g., router configuration, virtual machines, secure account handling and simple automation), not adapted from DigComp 2.2; the DigComp framework was used as a conceptual reference for mapping the digital domain. Participant-profile question 9 asked laptop/desktop-use frequency with options almost never, occasionally, weekly and daily, used in descriptive comparisons with digital indicator scores, not as a causal predictor.

For reporting purposes, electrical test items originally labeled B1–B15 in the participant questionnaire are referred to as E1–E15, and digital test items originally labeled A1–A25 are referred to as D1–D25. Indicator codes remain B1–B5 (electrical) and A1–A7 (digital). This reporting convention does not alter the administered instrument, answer key, or scoring.

The diagnostic was administered under instructor supervision on 13 October 2026, the first day of the face-to-face phase; one trainee completed it the following day under equivalent supervision. The earlier online phase used synchronous teaching from 08:00 to 12:00 and asynchronous, open-resource Google Classroom activities from 13:00 to 16:00. The diagnostic therefore represents knowledge available at the start of practical face-to-face instruction, not a baseline before all teaching. Online grades were neither compared statistically with diagnostic scores nor treated as proof of individual practical readiness, because proctored and unproctored administrations can yield systematically different scores (Steger et al., 2021). Data use was authorized by the training unit on 8 October 2026; the study did not undergo a separate ethics committee review.

All 40 administered items were retained in the reported diagnostic scores to preserve the predefined task-linked content coverage. Low or negative corrected item–total correlations were treated as exploratory warning signs rather than automatic exclusion criteria, given the small sample (n = 15); the affected items require further review of their scoring and performance in a larger sample.

KR-20 (Kuder & Richardson, 1937) was .76 for electrical items, .85 for digital items and .86 overall; confidence-scale alpha was .94. Among 35 nonconstant items, corrected item–total correlations were ≥ .30 for 26, .20–< .30 for five and < .20 for four (items E1 and E3 within indicator B1, D8 within A2 and D16 within A4; two were negative (E1: –.094; D8: –.207)); five universally correct items had undefined correlations. A sensitivity check found that electrical KR-20 decreased to .35 when the lowest-scoring trainee was excluded, indicating that the electrical reliability estimate depends substantially on individual observations in this small class. Thirty items were classified as easy and ten as moderately difficult; five of the easy items were answered correctly by all participants.

Item difficulty was defined as the proportion of trainees answering an item correctly (p). For descriptive classification, items with p ≤ .30 were considered difficult, .30 < p ≤

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.70 moderately difficult, and p > .70 easy. These categories describe performance in the present sample and do not represent competency-pass thresholds.

### 2.3. Analysis

We reported frequencies and descriptive score summaries; major-group comparisons were exploratory because subgroups were small. The association between mean digital confidence and the digital knowledge score was summarized using Pearson's r, a two-sided p-value and a Fisher-z 95% confidence interval, with Spearman's rank correlation as a robustness check. Each indicator gap equaled 100 minus the percentage of correct responses, in percentage points. The 25-percentage-point prioritization flag identifies indicators with at least one quarter of responses incorrect or unknown, providing a practical planning signal rather than a competency-pass criterion. Sensitivity was examined using gap cut-offs of 20, 25 and 30 points and concentration cut-offs of 50%, 60% and 70%. Bootstrap percentile intervals (95%) were estimated using 4,000 participant-level resamples with replacement; reproducibility settings are documented in Appendix A3. The original software environment was not recorded; independent verification of item statistics was conducted using Python 3.13.5, NumPy 2.3.5 and SciPy 1.17.0. Concentration was flagged when trainees scoring below 50% on an indicator contributed at least 60% of that indicator's incorrect responses; this rule was also heuristic. Sensitivity to exclusion of the lowest overall scorer was examined.

RQ2 mapping was conducted through document analysis in four steps: (1) recording competency units, JP and competency elements in the official curriculum (Kementerian Ketenagakerjaan Republik Indonesia, 2025); (2) identifying the actions and prerequisite knowledge required at each step of the job sheets and the practical demonstration; (3) matching these demands to indicators in the diagnostic blueprint (Appendix A2); and (4) recording the basis of each link as a unit, job sheet or task step (Appendix A1). The mapping was prepared by the researchers and confirmed by a program instructor; links indicate knowledge relevance, not evidence that practical competence was tested. Content, process and interim-product adaptations were proposed from gap size, error dispersion and task sequence, without implementation or outcome evaluation.

## 3. RESULTS AND DISCUSSION

### 3.1. Participant Profiles and Domain Asymmetry (RQ1)

Across 90 administrative records, 43 trainees had general secondary education (47.8%), 40 vocational secondary education (44.4%) and seven tertiary education (7.8%); 55.6% were therefore not vocational high-school graduates. These administrative categories describe the educational composition of enrolled trainees. The mean age was 20.8 years and 84 trainees (93.3%) were men. Batch 5 included 15 diagnostic respondents from 13 majors; 12 reported no electrical work experience, 11 no computer/IT work experience and 13 no previous electrical/IT training.

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**Table 1.** Characteristics of Batch 5 diagnostic respondents (n = 15).

| Characteristic | Category | n (%) |
|---|---|---|
| Education | SMK | 7 (46.7) |
| | SMA | 2 (13.3) |
| | MA | 1 (6.7) |
| | S1/D4 | 5 (33.3) |
| Electrical work | None | 12 (80.0) |
| | <1 year | 2 (13.3) |
| | 1–3 years | 1 (6.7) |
| Computer/IT work | None | 11 (73.3) |
| | <1 year | 3 (20.0) |
| | 1–3 years | 1 (6.7) |
| Previous electrical/IT training | None | 13 (86.7) |
| | Yes | 2 (13.3) |
| Laptop/PC use | Almost never | 1 (6.7) |
| | Occasionally | 8 (53.3) |
| | Weekly | 0 (0.0) |
| | Daily | 6 (40.0) |
| Educational major (analysis grouping) | IT-related | 4 (26.7) |
| | Other technical | 6 (40.0) |
| | Nontechnical/general | 5 (33.3) |

The overall mean diagnostic knowledge score for Batch 5 was 77.7 (SD 16.1) on a 0–100 scale; electrical and digital domain scores were 77.3 (SD 19.5) and 77.9 (SD 18.6), respectively (Table 2). Six of 15 trainees (40%) differed by at least 20 percentage points between domains. Descriptively, IT-major trainees (n = 4) averaged 89.0 in digital and 71.7 in electrical knowledge, whereas other technical majors (n = 6) averaged 91.1 in electrical and 76.7 in digital knowledge. These descriptive differences highlight domain-specific variation relevant to indicator-level instructional support; the small subgroups (n = 4 and n = 6) do not support generalization.

**Table 2.** Descriptive statistics of diagnostic knowledge scores (n = 15).

| Knowledge domain | Items (n) | Mean score | SD |
|---|---|---|---|
| Electrical knowledge | 15 | 77.3 | 19.5 |
| Digital and system integration | 25 | 77.9 | 18.6 |
| Overall diagnostic knowledge | 40 | 77.7 | 16.1 |

*Note.* Scores are scaled to 0–100. SD denotes sample standard deviation (n – 1). The 40-item overall score is computed from all items (15 electrical and 25 digital), not from the unweighted mean of the two domains.

Digital self-confidence averaged 2.84/4 and was positively associated with digital knowledge (Pearson r = .712, two-sided p = .0029, 95% CI [.314, .897]; n = 15). Spearman's rank correlation supported the same direction (ρ = .685, p = .0048). The association provides supplementary context for interpreting digital knowledge profiles; indicator-level diagnostic results remain the primary basis for task-specific instructional planning.

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### 3.2. Occupational-Task Mapping (RQ2)

The electrical block includes safety, measurement, earthing, protective devices and low-voltage installation, while the digital block comprises embedded/IoT systems, building automation and security (Table 3). The locally documented 240-minute final demonstration requires installation and verification followed by device/cloud integration, visualization and automation. The curriculum allocates JP to competency units, not to diagnostic indicators, so the analytical electrical/digital grouping should not be read as a ranking of gap severity; Appendix A1 traces each unit to the indicators it draws on. The measurement unit explicitly requires selection of suitable measuring equipment and connection of the correct circuit to obtain specified measurements (Kementerian Ketenagakerjaan Republik Indonesia, 2025), which gives the voltmeter results reported in Section 3.3 direct occupational relevance.

**Table 3.** Official program units grouped analytically and linked to diagnostic indicators.

| Program block | Duration | Task examples | Linked indicators |
|---|---|---|---|
| Electrical | 86 JP | Measurement, earthing, distribution board, wiring and testing | B1–B5 |
| Digital/integration | 106 JP | Microcontroller, router, Home Assistant, cloud devices, security and dashboard | A1–A7 |
| Supporting skills | 8 JP | Program supporting skills | Not tested as a separate domain |
| Integrated assessment | 240 min (local) | Electrical installation, cloud integration, visualization and automation | B1, B3–B5; A1–A7 (task-dependent) |

### 3.3. Indicator Gaps and Error Distribution (RQ3)

The six indicators meeting the operational gap threshold were electrical measurement (B2) and dashboard visualization (A6), both 33.3 points; operating systems/applications (A1), 31.7; electrical quantities (B1), 28.9; smart-home server setup (A3), 28.3; and wiring/switch functions (B4), 25.0 (Table 4). These gaps represent the proportions of incorrect or "I do not know yet" responses relative to a perfect test score. Bootstrap intervals were wide, so the flagged indicators should be interpreted as a priority group rather than a strict ranking.

**Table 4.** Gaps, bootstrap intervals and error patterns for all 12 diagnostic indicators (n = 15).

| Code / prerequisite | Correct (%) | Gap (pp) | 95% bootstrap CI (gap) | Pattern |
|---|---|---|---|---|
| B2 Electrical measurement | 66.7 | 33.3 | 17.8–51.1 | Dispersed |
| A6 Dashboard visualization | 66.7 | 33.3 | 13.3–56.7 | Concentrated |
| A1 OS/applications | 68.3 | 31.7 | 18.3–45.0 | Dispersed |
| B1 Electrical quantities | 71.1 | 28.9 | 17.8–42.2 | Dispersed |
| A3 Server setup | 71.7 | 28.3 | 11.7–48.3 | Concentrated |
| B4 Wiring/switches | 75.0 | 25.0 | 11.7–40.0 | Dispersed |
| A5 Account security | 80.0 | 20.0 | 6.7–35.6 | Concentrated |
| A2 Networks | 81.3 | 18.7 | 10.7–26.7 | Dispersed |
| B3 Protection components | 84.4 | 15.6 | 6.7–26.7 | Dispersed |
| A4 Cloud integration | 86.7 | 13.3 | 3.3–25.0 | Dispersed |
| A7 Automation/troubleshooting | 86.7 | 13.3 | 4.4–24.4 | Dispersed |
| B5 Safety and testing | 96.7 | 3.3 | 0.0–10.0 | Not flagged |

*Note.* Gap = 100 − percentage correct. Pattern is a descriptive rule (Section 2.3), not a psychometric diagnosis or significance test.

Sensitivity analysis flagged seven, six and three indicators at gap cut-offs of 20, 25 and 30 points, respectively; B2, A1 and A6 were retained under all three cut-offs. For

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concentration cut-offs of 50%, 60% and 70%, four, three and two indicators were flagged, respectively; A5 and A6 remained concentrated throughout. At the 50% concentration cut-off, electrical measurement (B2) also met the concentration criterion, although it was classified as dispersed under the prespecified 60% rule. Thus, A5 and A6 retained their classifications across the tested cut-offs, while B2 and A3 were threshold-sensitive.

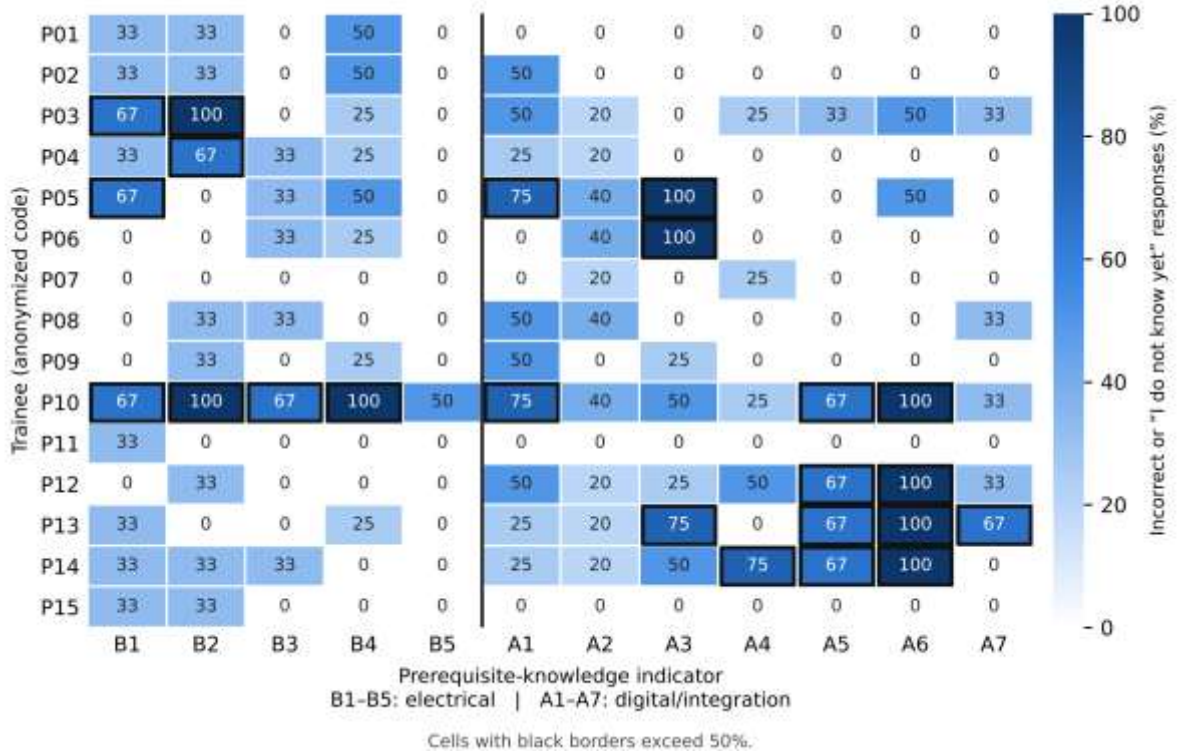



**Figure 1.** Proportion of incorrect or "I do not know yet" responses by trainee and indicator (n = 15).

As shown by the indicator-level error patterns in Table 4 and Figure 1, and under the stated descriptive rule, errors in A3, A5 and A6 were concentrated among trainees scoring below 50% on the respective indicator, making them candidates for targeted troubleshooting support, whereas errors in measurement, electrical quantities, application installation and wiring were dispersed, making them candidates for class-wide reinforcement. Six trainees scored below 50% on at least one of indicators A3, A5 and A6; all six reported using a laptop or desktop computer less than daily, although this use pattern was reported by nine of the 15 participants (Table 5). Laptop/PC-use frequency may serve only as a tentative cue for additional diagnostic checking. Unlike vocational digital-competence studies based on self-report (Mohamad et al., 2025), this association emerged from indicator-level knowledge-test responses linked to trainees' reported computer-use frequency. Excluding the lowest overall scorer (15/40) retained five of the six priority indicators at ≥ 25 points, while the B4 wiring gap fell from 25.0 to 19.6 points; this exploratory exclusion did not change the primary n = 15 analysis. Item-level responses revealed two patterns. On the voltmeter-connection item (indicator B2), eight of 15 trainees (53%) answered incorrectly and none chose "I do not know yet"; their answers clustered on series or phase-to-earth connections. On the earthing-conductor color item (B4), five of the seven incorrect responses were "I do not know yet". Incorrect responses to the voltmeter-connection item may indicate conceptual difficulties consistent with those reported in electrical-circuit research (Engelhardt & Beichner, 2004), whereas acknowledged non-knowledge can be addressed with explicit information. These responses indicate potential conceptual difficulties but do not

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establish misconceptions, because response certainty and participants' reasoning were not assessed (Hasan et al., 1999; D. Setiawan & Jaelani, 2021).

**Table 5.** Laptop/PC use frequency and digital indicator knowledge scores (n = 15).

| Laptop/PC use | n | A3 Mean Correct (%) | A5 Mean Correct (%) | A6 Mean Correct (%) |
|---|---|---|---|---|
| Almost never | 1 | 50.0 | 33.3 | 0.0 |
| Occasionally | 8 | 53.1 | 75.0 | 56.2 |
| Weekly | 0 | — | — | — |
| Daily | 6 | 100.0 | 94.4 | 91.7 |

*Note.* Mean percentages are based on knowledge-test responses rather than observed practical performance. Weekly use was an available response option but was not selected.

Gap size is not the only basis for instructional decisions. B2 and A6 both had 33.3-point gaps but differed in two respects: B2 errors were dispersed across many trainees and concern measurement verification before an installation is energized, whereas A6 errors were concentrated among a few trainees and concern visualization after device integration. B2 is therefore a candidate for shared conceptual reinforcement and demonstration, while A6 calls for individual checking and targeted support. A3 and A5 likewise suggest targeted support, and A1, B1 and B4 suggest shared reinforcement. In the context of heterogeneous vocational learning needs (Compen et al., 2025), this mapping allows instructors to differentiate assistance without changing common competency standards. These results build on research using diagnostic assessment to support differentiation in Indonesian vocational schools (Pradana et al., 2026; Wardhani, 2023) and extend it through individual error-distribution mapping aligned with sequential smart-building tasks. Research on differentiated instruction in vocational contexts likewise emphasizes adapting support to observed learning needs (Compen et al., 2025, 2026). The item-level measurement difficulties also resonate with findings from vocational high school students in Kendari, where Trisnawati et al. (2020) identified difficulties in DC-circuit concepts using four-tier diagnostic testing. Unlike that design, this study interprets incorrect voltmeter answers as signals for follow-up checking rather than confirmed misconceptions.

The low B5 knowledge gap (3.3 points) comes from only two knowledge items and does not establish safe practical performance. Voltmeter connection, conductor identification and safe testing can be checked directly through supervised job-sheet tasks. In competency-based training, diagnostic knowledge evidence informs preparation for practical assessment, while competency achievement is evaluated against the relevant task criteria (Kementerian Ketenagakerjaan Republik Indonesia, 2014).

### 3.4. Differentiated Instructional Implications (RQ4)

Diagnostic mapping shows the practical value of assessment as an instructional decision tool: instructors can identify indicators that require reinforcement, distinguish whether difficulties are dispersed or concentrated among some trainees, and then adapt content, process and interim evidence of progress. The proposed strategy combines shared reinforcement for dispersed electrical and application weaknesses with checks and targeted support for server configuration, dashboard visualization and account security (Table 6). These indicator-specific adaptations provide an evidence-informed framework for organizing instructional support, with flexible grouping and common final competency standards for all trainees.

A feasible instructional sequence is to check electrical quantities, meter use and wiring during guided practice, and then check local networking and server access before dashboard configuration. Evidence of progress should come from observable job-sheet

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checkpoints, such as correct connections, measured values and successful device communication, rather than from prior educational labels. Support can be faded once each trainee meets the same task criteria. An illustrative nine-JP integrated support allocation is provided in Table 7.

**Table 6.** Proposed differentiation of content, process and interim products under common final competency standards.

| Need / indicators | Content and process adaptation | Interim evidence; final standard |
|---|---|---|
| B1–B2 Electrical quantities and measurement | Shared worked examples, meter-range demonstration, stepped measurement job sheet and pre-energization checkpoint | Calculation/measurement record; same practical assessment |
| B4 Wiring | Color-coded diagrams; guided-to-independent distribution-board wiring and inspection | Tested wiring and inspection record |
| A1 Applications | Shared OS-specific installation guide, demonstration and individual practice | Application installed and launched |
| A2–A3 Networking/server setup | Network connectivity checks and small-group virtual-machine/Home Assistant checkpoints with targeted peer support | Verified network access, accessible server and troubleshooting log |
| A5–A6 Security/dashboard | Targeted credential-handling exercises and progressively less scaffolded floor-plan dashboard tasks | Secure account and functioning visualization |

**Table 7.** Illustrative allocation of differentiated instructional support within existing 200 JP.

| Training focus | Indicators | Proposed time | Integrated into |
|---|---|---|---|
| Electrical quantities and measurement | B1–B2 | 3 JP | Electrical measurement unit |
| Wiring and switching | B4 | 1 JP | Low-voltage installation activities |
| Application installation | A1 | 1 JP | Digital practical activities |
| Server/network configuration | A2–A3 | 2 JP | Building automation activities |
| Account security and dashboard | A5–A6 | 2 JP | BAS/security practical activities |
| Total | — | 9 JP | Within existing 200 JP |

Kurniawati et al. (2025) developed a project-based module to support vocational learning, illustrating how instructional materials can be organized around practical tasks. Erwis et al. (2025) reported the contribution of project-based learning to vocational students' soft-skill development. Its focus on intervention outcomes complements the present study's emphasis on identifying prerequisite knowledge profiles before planning support; the difference underscores the role of diagnostic mapping in sequencing learning assistance. Indonesian SMK diagnostic work has addressed language learning (Wardhani, 2023) and digital diagnostic design (Pradana et al., 2026), while this study connects observed electrical–digital knowledge gaps to participant-level error patterns and smart-building task demands. In electrical conceptual assessment, (D. Setiawan and Jaelani, 2021) used a five-tier diagnostic approach, highlighting how reasoning about technical knowledge can be probed beyond total scores. These strands jointly position indicator mapping as a bridge between diagnostic evidence and task-based instructional planning. Digital-domain variation can also be compared with Hafizh et al. (2026), who profiled DigComp 2.2 digital skills among 65 mechanical engineering students at a vocational high school in Serang. Their emphasis on domain-specific digital skills complements this study's task-aligned diagnostic knowledge mapping, although the measured competencies and instruments differ.

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Instructors could regroup trainees flexibly on the basis of job-sheet checkpoints rather than assigning permanent groups by qualification or online grades. In this study, instructional decisions were derived from the relationship between diagnostic error profiles, competency-unit demands and observable evidence at practical stages. This instructional sequence is consistent with vocational electrical jobsheet development (Wardoyo et al., 2026) and approaches to remedial and enrichment support (Suhendar et al., 2023). Project-based learning research in electrical/electronics vocational education provides an additional basis for task-centered instruction (Akhyar et al., 2024). At the institutional level, administrative admission criteria and diagnostic assessment serve complementary functions: admission establishes eligibility, whereas indicator-level diagnostic results provide actionable information for planning support within the existing project-based training sequence (Kementerian Ketenagakerjaan Republik Indonesia, 2025; Wardhani, 2023).

### 3.5. Limitations

The diagnostic assessment was conducted once in a single class of 15 participants at the transition to face-to-face training; the administrative records of 90 trainees provide enrollment context rather than diagnostic responses. The instrument measured prerequisite knowledge rather than practical performance: 30 of 40 items were classified as easy and five were answered correctly by every participant. Two-item indicators (A6 and B5) were particularly sensitive to individual responses, and mapping links were not independently double-rated. The 25-point and 60% flags are exploratory planning thresholds, not competency standards. Content review was conducted by two qualified experts affiliated with the institution, without an additional external review. The first author's institutional role as an instructor, although not the teacher of this class during data collection, and the absence of a separate institutional ethics committee review are acknowledged. Institutional permission, individual written consent, anonymized records, and predefined scoring procedures were used. Findings from further cohorts and practical task assessments will inform refinement of the diagnostic approach.

## 4. CONCLUSION

This study identified six priority prerequisite-knowledge indicators with gaps ranging from 25.0 to 33.3 percentage points among 15 trainees in the Installation of Smart Building Integration Systems program at BBPVP Serang. Indicators with similar gap magnitudes exhibited different distributions of errors, supporting the value of examining individual diagnostic patterns alongside aggregate scores. The study contributes a task-aligned approach connecting electrical and digital prerequisite knowledge, error distribution and the sequence of practical tasks with differentiated instructional planning. For BBPVP Serang, this offers a basis for integrating structured diagnostic assessment into the transition to face-to-face practical training and using the resulting profiles to organize shared reinforcement, targeted assistance and flexible job-sheet support while maintaining common final competency standards. Future research can evaluate these strategies across multiple training cohorts and assess outcomes through practical competency performance. Follow-up studies may combine practical performance assessments with multi-tier diagnostic items or response-certainty measures to investigate the sources of persistent errors.

## 5. AUTHORS' NOTE

**Author contributions (CRediT):** Devia Rafika Putri: conceptualization, methodology, investigation, data curation, formal analysis, visualization, writing—

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original draft. Suhendar: supervision, methodology, writing—review and editing. Siswo Wardoyo: supervision, writing—review and editing.

**Conflict of interest:** The first author is employed as an instructor at BBPVP Serang and was not responsible for teaching the participating class during diagnostic administration.

**Data availability:** De-identified diagnostic responses and institutional administrative records are held by the researchers; access is subject to institutional permission and participant confidentiality.

**Ethics statement:** The training unit granted institutional data-use permission on 8 October 2026. All 15 participants were adults and provided individual written informed consent. Participation was voluntary, participant identities were coded, and diagnostic results did not affect completion or competency-assessment decisions. A separate institutional ethics committee review was not obtained.

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