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From Classroom to Industry: What Truly Improves Green Skills in Indonesian Vocational High Schools?

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Abstract: Indonesia's green transition requires vocational graduates who are not only technically competent, but also possess green skills (GS) in the cognitive (CC), interpersonal (IC), and intrapersonal (IaC) domains. This study aims to map the level of GS, patterns between domains, and learning factors in Indonesian vocational education by conducting a quantitative secondary synthesis of five Scopus-indexed studies (2015-2025). The methods used include structured book coding, metric harmonization, and the SWiM framework with voice calculation based on effect direction (↑, →, ↓, NR). The results show a gap between students and teachers: the average GS scores of students (2.188-2.594) were lower than those of teachers (2.242-2.917), with two of the three studies placing student GS in the low category. One intervention module showed a moderate improvement (N gain = 0.4; average score from 46.7 to 73.3). IC was consistently positive (3 out of 3 studies ↑), IaC was mixed (2 positive, 1 negative), and CC was varied (1 positive, 1 neutral, 1 negative). A survey of 562 Islamic vocational school students showed a positive relationship between religious and environmental values and GS. These findings highlight the importance of GS modules, values-based education, and green school culture.

Keywords: Green skills School–industry ecosystems; TVET; Vocational education; Vote counting

Introduction

The transition toward a green economy has become a strategic agenda in many countries, including Indonesia. This shift in development direction not only demands technological innovation and policy reform, but also a transformation in the quality of human resources who will act as the main agents in the world of work (Araújo et al., 2024). In this context, vocational education, particularly vocational high schools (SMK), plays a pivotal role because it directly prepares graduates to respond to industry needs (Haloho et al., 2023). Consequently, SMK is not only tasked with producing technically competent graduates, but is also required to equip them with the capacity to implement sustainable and environmentally responsible work practices (Saputri & Ediyono, 2022).

In line with these demands, green skills (GS) have emerged as one of the core competencies that must be cultivated in vocational education (Fitriyanto et al., 2024). Green skills encompass three main domains, namely cognitive competence (CC), interpersonal competence (IC), and intrapersonal competence (IaC) (Diplan et al., 2020). The cognitive domain refers to knowledge and understanding of environmental concepts, principles, and issues; the interpersonal domain emphasizes the ability to collaborate, communicate, and work together in implementing sustainable practices; while the intrapersonal domain concerns attitudes, values, motivation, and personal responsibility toward the environment (Fitriyanto et al., 2023). These three domains do not operate in isolation, but interact with one another and collectively shape sustainable work behavior among teachers and

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students, so that each domain has an indispensable role in the development of green skills (Amin & Maritasari, 2023). Therefore, strengthening green skills effectively is crucial to meeting the needs of a sustainable workforce and supporting the achievement of environmental sustainability goals (Setyaningrum & Muafi, 2023).

A range of policies and initiatives has encouraged the integration of green skills into the curriculum of many vocational schools in Indonesia (Mutohhari et al., 2025). However, the implementation of GS in classroom practice and in industrial settings still encounters various challenges (Zulkarnaen & Prasto, 2023). One of the key issues widely reported is the gap in understanding between teachers and students regarding green skills (Muaddab et al., 2024). Teachers generally possess a deeper grasp of the terminology, concepts, and urgency of GS than students (Handayani et al., 2020b). This gap indicates that the design and implementation of learning processes have not yet fully succeeded in bridging these differences in understanding (Ramli et al., 2020). As a result, efforts to reinforce students' understanding, particularly in relation to the cognitive, interpersonal, and intrapersonal domains, still require a more focused and systematic approach (Utami et al., 2023).

At the same time, previous studies on green skills in Indonesian vocational education indicate that research foci tend to be fragmented (Olzhebayeva et al., 2024). Many studies concentrate mainly on developing or measuring a single domain of green skills, for example, focusing only on the cognitive aspect through enhancing environmental knowledge or only on the dimension of attitudes and concern (A. Rahman et al., 2025). This situation has resulted in a less comprehensive understanding of how the three domains, namely cognitive, interpersonal, and intrapersonal, simultaneously contribute to green skills comprehension among vocational teachers and students. In other words, there remains a research gap concerning the comprehensive mapping of each domain's contribution to the overall achievement of green skills in the context of vocational education in Indonesia (Riswano, 2023).

Responding to this gap, the present study offers novelty by seeking to map and compare the three domains of green skills in an integrated manner. This study examines which domain tends to be more dominant or exhibits a more consistent pattern of improvement in enhancing green skills understanding among vocational school teachers and students. To this end, a scoping review approach is employed by synthesizing findings from five empirical studies indexed in the Scopus database and conducted in Indonesia. This approach is expected to provide a broader and more systematic empirical picture of the contribution of each green skills domain within the framework of sustainable vocational education. In line with the foregoing background, the objectives of this study are formulated in the following Research Questions (RQ): RQ1: To what extent is the level of understanding of green skills among vocational school teachers and students? RQ2: Which green skill domain (cognitive, interpersonal, intrapersonal) shows the most consistent improvement pattern across all studies? RQ3: What learning approaches can be applied to improve green skills among vocational school teachers and students?

Method

Design

This subsection presents the study's overall design and analytical workflow. Figure 1 provides a visual summary of the sequential procedures, illustrating how primary studies were identified, selected, coded, and synthesized.

Figure 1. Analytical workflow for the quantitative secondary synthesis of green skills studies

At the identification stage, potentially relevant articles were retrieved from Scopus by searching the Title–Abstract–Keywords fields using combinations of terms related to green skills and education, with filters applied for publication year (2015–2025), document type, and primary research conducted in educational

settings. During screening, titles and abstracts were reviewed to remove irrelevant records, followed by full-text assessment against the following inclusion criteria: (i) reporting quantitative empirical data, (ii) conducted in Indonesia, (iii) focusing on vocational education/TVET (vocational high schools and agribusiness/engineering programs), and (iv) providing extractable quantitative GS outputs. Only articles written in Indonesian or English and published in Scopus-indexed peer-reviewed journals were retained (Suryawan et al., 2024).

Applying these criteria yielded a final corpus of five empirical articles. For each study, data were extracted using a structured codebook to capture study characteristics and all reported GS indicators, which were then harmonized and mapped onto three generic GS domains—cognitive (CC), interpersonal (IC), and intrapersonal (IaC)—without altering the substantive meaning of the original measures (Nasution et al., 2024). Subsequently, effect-direction vote counting was implemented within the SWiM (Synthesis Without Meta-analysis) framework, coding the effect direction of each study–domain combination as increasing (↑), neutral (→), or decreasing (↓), based on GS level, pre–post change (e.g., N-gain), and the sign and statistical significance of the relationship coefficients (Yudatama et al., 2025). This procedure aligns with SWiM guidance for syntheses involving few studies and heterogeneous outcomes, enabling the contribution patterns of each GS domain to be mapped in a systematic and transparent manner.

Corpus Source

The research corpus is defined as a fixed set of five empirical journal articles that present quantitative evidence on green skills (GS) within vocational education in Indonesia. These studies were identified from the Scopus database by applying the eligibility criteria outlined in the following subsection. All five focus on GS in the Indonesian context and involve key vocational education stakeholders, including agricultural vocational school teachers, meat processing technology students, teachers and students at Adiwiyata vocational schools, agribusiness industry practitioners, and students at Islamic vocational schools.

The articles, published between 2020 and 2025 in Scopus-indexed peer-reviewed journals, provide extractable quantitative outputs related to GS (Shaherani et al., 2024), such as levels or categories, proportions, N-gain values, and correlation or path coefficients. Table 1 summarizes this fixed corpus in terms of article title, year of publication, research design, primary subjects, and sample size.

Table 1. Fixed Corpus of Empirical Studies on Green Skills in Indonesian Vocational Education

ID_Study	Title	Year	Design	Subject	N
S1	Green Skills Understanding of Agricultural Vocational School Teachers around West Java Indonesia	2020	Survey (online) + short interview	Agricultural vocational school teachers	NR
S2	Development of Green Skills Module for Meat Processing Technology Study	2021	R&D (ADDIE) + pre–post testing	Vocational high school students (meat-processing technology)	48
S3	Generic Green Skills: Maturity Level of Vocational Education Teachers and Students in Indonesia	2025	Multi-school analytic survey	Vocational school teachers and students (8 Adiwiyata schools)	269
S4	Industry Perceptions on the Need for Green Skills in Agribusiness Vocational Graduates	2020	Survey	Agribusiness industry practitioners	NR
S5	Promoting Islamic Values for Green Skill Development in Islamic Vocational High Schools	2024	Survey	Islamic vocational high school students	NR

Inclusion and Exclusion Criteria

The research corpus comprised five Scopus-indexed empirical articles on green skills (GS) in vocational education in Indonesia. To ensure transparency and reproducibility, this subsection specifies the inclusion and exclusion criteria used to select the studies. Articles were retained only if they fulfilled all inclusion criteria (I1–I6) and did not meet any exclusion criteria (E1–E4). Feasibility was assessed at the full-text level, using tables and figures as supporting evidence (Lubis et al., 2024). A summary of these criteria is presented in Table 2.

Table 2. Inclusion and Exclusion Criteria

Type	Code	Brief Criteria	Operational Test
Inclusion	I1	Empirical quantitative primary research	The article reports primary quantitative data (e.g., survey, experiment, R&D, or mixed-methods with extractable quantitative results) and includes numerical analysis in the Methods/Results sections.

Type	Code	Brief Criteria	Operational Test
Inclusion	I2	Indonesian context	The research setting, sample, or educational institution is located in Indonesia, as indicated by the study location, institutional affiliation, or contextual description.
Inclusion	I3	Vocational education / vocational school / TVET	The population consists of students, teachers, curricula, or programmes in vocational schools or TVET institutions (including agribusiness and technical programmes).
Inclusion	I4	Explicit focus on green skills (GS)	GS is a central construct in the study and is defined and/or operationalised through indicators, dimensions, or measurement instruments.
Inclusion	I5	Extractable quantitative GS outcomes	The article reports numerical results related to GS (e.g., levels or categories, percentages, N-gain, correlation or path coefficients) that can be coded into the extraction matrix.
Inclusion	I6	Scopus-indexed journal article in Indonesian or English, 2015–2025	The article is published in a peer-reviewed journal indexed in Scopus, written in Indonesian or English, and falls within the 2015–2025 publication window.
Exclusion	E1	Narrative reviews, theoretical papers, or opinion pieces	The article does not report primary quantitative data; content is limited to conceptual discussion, commentary, or policy views.
Exclusion	E2	Outside vocational or TVET education	The study setting is not related to vocational education, vocational schools, or TVET (e.g., purely corporate or community contexts without a formal educational institution).
Exclusion	E3	Green skills not substantiated	GS is mentioned only briefly or rhetorically, without any operational definition, indicators, or measurement tools in the Methods or Results sections.
Exclusion	E4	No quantitative outcomes	All findings are purely qualitative, with no numerical measures that can be extracted for GS (e.g., interview-only studies without statistics, scores, or percentages).

Data Extraction and Codebook

Data extraction was carried out using a structured worksheet (codebook) designed to maintain consistency across studies and ensure alignment with the three research questions guiding this secondary synthesis. The codebook was organized into three blocks of variables: (i) study identity and contextual information, (ii) green skills (GS) outcomes categorized by domain, and (iii) pedagogical or contextual factors associated with GS and the direction of their effects. Collectively, these blocks provide the information necessary to characterize the included studies, evaluate GS status across domains, and identify accompanying pedagogical or contextual attributes (Syskowski et al., 2024).

Each column in the codebook was completed based on details reported in the primary studies, primarily drawn from the Methods and Results sections. Numerical values and categorical labels were cross-verified across text, tables, and figures. Variables not reported in the original articles were coded as NR (Not Reported) and were not imputed(Wisudawati & Barke, 2024). Table 3 outlines the codebook columns, their operational definitions, and their analytical roles in addressing the research questions.

Table 3. Codebook Scheme and Main Analytical Use

Column	Description	Main Analytical Use (RQ)
Study_Id	Unique identifier per article (S1–S5)	Study identity and comparison (RQ1)
Year	Publication year	Temporal profile of the corpus (RQ1)
Design	Research design (e.g., survey; R&D (ADDIE) + pre–post)	Methodological profile of studies (RQ1)
Subject	Main population/sample (e.g., teachers, students, industry practitioners)	Characterisation of actors involved (RQ1)
N	Total sample size	Study scale and coverage (RQ1)
Dimension_GS_reported	GS domains covered (cognitive/CC, interpersonal/IC, intrapersonal/IaC)	Coverage of GS domains across studies (RQ2)
Category_level_GS	Reported GS level categories (e.g., very low–very high)	Status/level of GS in each study (RQ2)
GS_understanding_proportion (%)	Proportion in specific GS categories or indicators	Distribution of GS across categories (RQ2)
N_gain_prepost	N-gain values in pre–post designs	Change in GS following interventions (RQ2)

Column	Description	Main Analytical Use (RQ)
R_beta_construction	Correlation or path coefficients involving GS	Strength and direction of GS relationships (RQ2)
Pedagogical_context_factor	Pedagogical approach, intervention, or contextual factor related to GS (e.g., module, Islamic values, school culture, industry expectations)	Pedagogical and contextual characteristics linked to GS (RQ3)
Direction_of_effect	Effect direction per study (↑ / → / ↓) based on harmonised indicators	Cross-study pattern of GS effects (RQ3)

Extraction followed a set of predefined operational rules. For GS levels, the categories and thresholds reported by the original authors were retained. When only mean scores were available and no explicit level thresholds were provided, the level categories were coded as NR, while the raw scores were preserved for contextual interpretation. Proportion values (percentages) were transcribed as reported, and for mutually exclusive categories, simple checks were conducted to ensure that their totals approximated 100%.

For pre–post designs, reported N-gain values were used directly. When N-gain was not provided but pre-test, post-test, and maximum scores were available, N-gain was calculated and documented in the extraction file. Correlation coefficients (r) and path coefficients (β) were recorded together with their signs and statistical significance, without aggregating or comparing models that were not methodologically comparable.

Metric Harmonization

Metric harmonization was implemented in two stages: (1) assigning each indicator to one of three generic green skills (GS) domains—cognitive competence (CC), interpersonal competence (IC), and intrapersonal competence (IaC); and (2) standardizing the handling of numerical metrics and differences in measurement scales. CC encompasses knowledge and understanding of sustainability and green work practices; IC covers communication, teamwork, and coordination in green-oriented activities (Latif et al., 2025); whereas IaC includes attitudes, motivation, self-management, adaptability, and green entrepreneurial orientation (Latif et al., 2024). In the five primary studies, each GS indicator was classified into CC, IC, or IaC according to these definitions. Composite scales spanning multiple domains were assigned to the domain judged most dominant based on the authors' descriptions, while unclear or insufficiently specified indicators were coded as Not Reported (NR) (Wiyatmi et al., 2023).

For numerical data, GS level categories (e.g., very low–low–high–very high) were retained according to the thresholds specified by the original authors. When only mean scores were available without explicit cut-off points, the level variables were coded as NR and the means were used only for contextual interpretation (Subyantoro et al., 2022). Proportions (percentages) were transcribed as reported and checked to ensure that totals for mutually exclusive categories approximated 100%. In pre–post designs, GS change was represented using N-gain values, either directly from the primary studies or calculated when pre-test, post-test, and maximum scores were fully reported. Correlation coefficients (r) and path coefficients (β) were recorded without further standardization, given the heterogeneity of models and constructs across studies. Most instruments employed Likert-type scales of varying lengths; no rescaling to a common metric was performed. Within each study, the interpretation of GS levels and changes followed the original scale, whereas cross-study synthesis relied only on level categories, effect signs, and statistical significance to determine effect direction, without directly comparing or averaging raw mean scores (Khoiri et al., 2023).

Quality Appraisal and Risk of Bias

Quality assessment was conducted to strengthen the interpretation of findings and to inform sensitivity analyses (Sharif et al., 2021), without introducing any additional exclusion criteria beyond the fixed corpus of five studies. The assessment rubric integrated several dimensions: clarity of research design reporting, sample reporting, instrument quality, completeness of outcome reporting, transparency of analytical procedures, reporting for each GS domain, potential selection or non-response bias, and disclosures related to funding and conflict of interest (COI).

Each criterion was rated on a three-point scale from 0 to 2 (0 = absent, 1 = partially present, 2 = adequately present). The sum of these eight criteria produced an overall quality score, which was subsequently mapped onto a risk-of-bias category: high, some concerns, or low. These categories served as an interpretive lens in the Results and Discussion section—for example, by highlighting studies with lower scores during sensitivity analysis—while leaving the composition of the research corpus unchanged.

Table 4. Quality Appraisal Rubric

Criteria	Assessment Definition	Score (0–2)
Clarity of design	The research design is explicitly stated (e.g., survey, R&D, pre–post), along with objectives and unit of analysis.	0 = unclear; 1 = partially clear; 2 = clear
Reporting of sample size and sampling	Sample size, recruitment/sampling methods, and main characteristics are reported.	0 = no; 1 = partial; 2 = complete
Instrument quality	Validity and/or reliability are reported, or expert validation is described for R&D/module studies.	0 = no; 1 = partial; 2 = adequate
Completeness of outcome reporting	Primary outcomes (levels, proportions, N-gain, relationships) are reported with numerical detail.	0 = no; 1 = partial; 2 = complete
Transparency of analytical procedures	Analytical steps (calculations, statistical tests) are described so they can be traced.	0 = no; 1 = partial; 2 = adequate
Reporting per GS domain (CC/IC/iac)	Reporting separates GS domains or explains clearly when this is not possible.	0 = no; 1 = partial; 2 = clear
Selection bias / non-response	Potential bias due to non-response or attrition is reported and managed.	0 = no; 1 = partial; 2 = adequate
Conflict of interest & funding	Funding/COI statements are provided and do not threaten the independence of the analysis.	0 = no; 1 = partial; 2 = clear

Table 5. Mapping of Total Score to Risk-of-Bias Category

Total Score (0–16)	Risk-of-Bias Category	Interpretation
0–5	High	Much of the core information is not reported; results are highly susceptible to bias.
6–10	Some concerns	Several aspects of reporting or validity are limited; interpretation requires caution.
11–16	Low	Reporting is generally adequate; major risks of bias appear to be managed.

Synthesis and Cross-Study Testing

This secondary synthesis uses the SWiM (Synthesis Without Meta-analysis) approach with the effect direction vote counting technique to summarize the patterns of findings from five heterogeneous studies on three domains of green skills (GS): cognitive (CC), interpersonal (IC), and intrapersonal (IaC). For each combination of studies and domains, the effect direction is determined based on previously harmonized GS indicators.

Effect direction was coded as increasing (↑), neutral (→), decreasing (↓), or Not Reported (NR). The code ↑ was assigned when the study reported high GS levels, positive and meaningful pre–post changes (e.g., positive N gain), or a statistically significant positive relationship. The code → was used when GS levels were stable or moderate and the reported effect was weak or insignificant. The ↓ code is used when GS levels are low, N gains are negative or very small, or the relationship is significantly negative. Combinations with inadequate or conflicting indicators are coded NR and excluded from the calculation (Veriasa et al., 2021).

After coding, the number of ↑, →, and ↓ is counted per domain and overall. The directional pattern of effects is visualized through a simple heatmap to review cross-study and cross-domain trends and identify potential outliers. Sensitivity analysis is performed by comparing these patterns when the interpretive weight of lower-quality studies or those with a high proportion of NR is reduced. Conclusions are considered robust if the dominant direction of effects remains consistent under these alternative weighting schemes (Anisah et al., 2025).

Result and Discussion

Study Characteristics

Five empirical articles on green skills (GS) in vocational education in Indonesia were included in this synthesis. Published between 2020 and 2025, these studies employed a mix of descriptive and analytical survey designs as well as research and development (R&D) approaches incorporating pre–post testing. The research settings encompassed agricultural vocational schools, Islamic vocational schools, multi-school environments with Adiwiyata status, and industry perspectives on vocational graduates. The quantitative indicators available across the corpus included GS levels or categories, proportions, N-gain values from pre–post assessments, and relational measures such as correlations and path coefficients.

The first study, published in 2020, conducted a preliminary survey of teachers at agricultural vocational schools in West Java. Although the exact sample size was not reported numerically, teachers from 15 agribusiness-focused schools were invited to participate. The study primarily assessed teachers' understanding of the term green skills and their perceptions of its relevance, rather than reporting detailed domain-specific GS scores (Handayani et al., 2020a).

The second study, published in 2021, developed and evaluated a green skills learning module for meat-processing technology programs in vocational schools. Using an R&D design based on the ADDIE model and involving pre- and post-tests with 48 students, the study

found the module to be highly feasible according to expert validation. The reported N-gain for students' green skills was 0.4, indicating a moderate improvement (Handayani et al., 2021).

The third study, published in 2025, examined generic green skills among teachers and students in eight Adiwiyata vocational schools. Employing an analytical survey design with descriptive statistics, ANOVA with post hoc tests, and path analysis, the study reported average scores for the cognitive, interpersonal, and intrapersonal GS domains separately for teachers and students. The findings indicated that students' overall GS levels were low, teachers' GS levels were high, interpersonal competence was the strongest domain, and intrapersonal competence was the weakest in both groups (Mutohhari et al., 2025).

The fourth study, also published in 2020, surveyed agribusiness industry practitioners regarding their perceptions of the green skills required of vocational school graduates. Although the exact sample size could not be verified from the available scanned manuscript, the study reported proportions and descriptive indicators reflecting how urgently respondents viewed various GS components and how they assessed the current profile of vocational graduates (Handayani et al., 2020c).

The fifth study, published in 2024, investigated green skills among students in Islamic vocational schools in Bogor. An analytical survey of 562 students was conducted to examine the influence of Islamic values and environmental behaviour on GS. The findings showed a significant positive influence of Islamic faith values and environmentally responsible behaviours such as planting activities and zero-waste practices on students' technical, managerial, and personal green skills (Fauziah et al., 2024).

Summary of Codebook and Reporting Completeness

This subsection summarizes the availability of variables extracted using the codebook described in the Methods section and the completeness of reporting in each article. Items that were not reported in the primary studies are coded as NR (Not Reported) (Amin & Maritasari, 2023; Najwa & Suhartini, 2023).

The mapping of GS domain levels onto the three competencies—cognitive (CC), interpersonal (IC), and intrapersonal (IaC)—is fully available in study S3. This mapping can be partially inferred in S2 and S5 based on the content of the indicators, but it is not presented in a form that allows direct allocation to CC, IC, or IaC in S1 and S4. Instrument quality is reported most clearly in S2, which provides expert validation of the developed modules, and in S3, which offers reliability and validity evidence for the GS instruments. The remaining studies provide limited or no psychometric information.

Study S2 reports an N-gain value of 0.4 for green skills. Study S3 provides GS levels by category—low for students and high for teachers and reports relationships between GS domains and other constructs. Studies S1 and S4 primarily present descriptive indicators and proportions, whereas S5 reports a statistically significant association between Islamic values, environmental behavior, and green skills.

Table 6 summarizes the coverage of key elements in the codebook and the completeness of reporting across the five included studies.

Table 6. Codebook Coverage and Reporting Completeness per Study

ID	Domain Per Dimension (CC/IC/Iac)	Instrument_Quality (Validity/Reliability)	Outcome_Level (1-4)	Outcome_Proportion (%)	Outcome N-Gain	Outcome_Relationship (R Or Beta)
S1	NR (GS understanding reported in aggregate)	NR	NR	✓	NR	NR
S2	Partial (indicators span several domains)	Expert validation reported	NR	NR	✓ (N-gain = 0.4)	NR
S3	✓ (domains reported separately)	Reliability and validity reported	✓ (low for students, high for teachers)	NR	NR	✓ (path and correlation models)
S4	NR (needs discussed in aggregate)	NR	NR	✓ (perceived GS needs)	NR	NR
S5	Partial (technical, managerial, personal skills)	NR or limited reporting on instrument quality	NR	NR	NR	✓ (significant associations with GS outcomes)

Answer to RQ1 — Levels/Maturity of Green Skills

RQ1 examines the level or maturity of green skills among teachers and students in Indonesian vocational education. Table 7 summarizes all indicators directly related to GS levels, pre–post changes, or other proxies of maturity.

Overall, three studies provide direct numerical evidence on GS levels or improvements (S1, S2, S3), and two studies offer indirect indications (S4, S5). In S1, the proportion of teachers unfamiliar with the term green skills suggests that GS literacy among teachers is

uneven, indicating that GS-related cognitive competencies remain weak for some respondents.

In S2, the GS-oriented learning module produced an increase in the average score from 46.7 to 73.3, with an N-gain of 0.4 classified as moderate. This indicates that structured module-based interventions can moderately enhance learning outcomes related to GS.

Table 7. RQ1 Indicators per Study and Interpretation

ID	Population	Main Indicator	Reported Metrics	GS Level (1-4)	N-Gain
S1	Agricultural vocational school teachers	Understanding of GS terminology	Proportions of teachers who recognise and correctly interpret GS terms (exact percentages not reported)	Not reported	-
S2	Vocational high school students in meat processing technology (n = 48)	Change in GS-related learning outcomes after a module	Mean pre-test score 46.7 and post-test score 73.3 on a 0-100 scale. Reported N-gain 0.4 on a 0-1 scale, classified as moderate	Not reported	0.4
S3	Vocational school teachers and students in eight Adiwiyata schools	Maturity level of GS by domain and group	Teachers: CC 2.639 (high), IC 2.917 (high), iac 2.242 (low). Students: CC 2.300 (low), IC 2.594 (high), iac 2.188 (low) on a four point scale	Students low, teachers high overall	-
S4	Agribusiness industry practitioners	Required GS profile for vocational graduates	Descriptive statistics of expectations and priority GS indicators. No GS level for current graduates is reported	Not applicable	-
S5	Grade XII students in Islamic vocational schools (n = 562)	Association between Islamic values and GS	ANOVA and regression with $p < 0.001$ for the effect of faith-related and pro-environmental behaviour indicators on GS scores. Exact GS means and thresholds are not reported	Not reported	-

In S3, average student scores ranged from 2.188 to 2.594, whereas average teacher scores ranged from 2.242 to 2.917 on the same four-point scale. Teachers fell into the high category for the cognitive and interpersonal domains, while students were in the low category for the cognitive and intrapersonal domains, with relatively higher scores in the interpersonal domain. This pattern points to a clear GS maturity gap between teachers and students, particularly in the intrapersonal domain.

In S4, the primary focus was on industry needs and expectations regarding GS rather than on measuring graduates' GS levels. Although no numerical levels were reported, the findings still signaled that GS is perceived as important and urgent by employers.

In S5, GS levels were not categorized, but ANOVA and regression analyses showed that indicators of Islamic values and pro-environmental behavior were significantly and positively associated ($p < 0.001$) with GS scores. In other words, variation in students' GS achievement was correlated with their degree of internalization of environmental values and practices.

In summary, RQ1 indicates that GS maturity in Indonesian vocational education is still uneven. Two of the three studies that reported levels classified students' GS as low, one study documented moderate improvement following a module intervention, and one study revealed weak literacy of GS terminology among a subset of teachers. Teachers generally achieved higher GS scores than students, and when domains were disaggregated, the intrapersonal domain consistently showed the lowest maturity.

Answer to RQ2 — Cross-Domain Patterns (CC, IC, IaC)

RQ2 investigates how patterns of green skills achievement emerge across the three generic domains—cognitive (CC), interpersonal (IC), and intrapersonal (IaC)—in the included studies. To address this question, each GS indicator in the five studies was mapped to one of these three domains and then coded for effect direction as increasing (↑), neutral (→), decreasing (↓), or not reported (NR), following the harmonization rules outlined in the Methods section. The resulting pattern of effects is visualized as a heatmap in Figure 2.

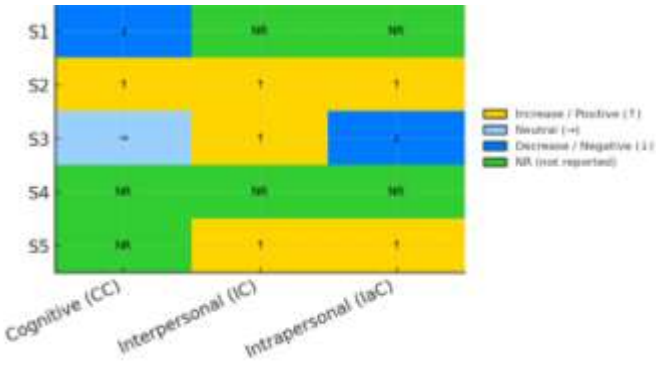

Figure 2. Heatmap of effect directions per domain

In the heatmap, yellow cells indicate an increasing effect (↑), light blue indicates a neutral effect (→), dark blue indicates a decreasing effect (↓), and green indicates

NR (not reported). The symbols in each cell represent the vote-count outcome for each study–domain combination.

Overall, S1 reports only teachers' literacy regarding GS terminology; consequently, the cognitive domain (CC) is coded as decreasing (↓), while the interpersonal (IC) and intrapersonal (IaC) domains cannot be mapped and are therefore coded as NR. In S2, the use of a structured GS module yields an N-gain of 0.4 on a composite GS score, so all three domains (CC, IC, IaC) are coded as increasing (↑). S3 reports mean scores by domain for both teachers and students: teachers fall into the high category for CC and IC, whereas students are low in CC and IaC and relatively higher in IC. Aggregated across groups, CC is coded as neutral (→), IC as increasing (↑), and IaC as decreasing (↓). S4 focuses on industry expectations regarding GS rather than on measurable GS scores, so all domains are coded as NR. S5 reports a significant positive effect of Islamic values and pro-environmental behaviour on managerial and personal skills, which are mapped to IC and IaC as increasing (↑), while CC is coded as NR because knowledge-related indicators are not disaggregated.

From this mapping, the vote count per domain can be summarized as follows. For interpersonal competence (IC), all three relevant studies (S2, S3, S5) show an increasing effect, yielding 3 out of 3 studies with a positive direction and none with neutral or negative effects. For intrapersonal competence (IaC), two of the three studies (S2 and S5) show an increasing direction and one study (S3) shows a decreasing direction, resulting in 2 out of 3 positive and 1 out of 3 negative. For cognitive competence (CC), among the three studies that can be mapped (S1, S2, S3), one study shows a positive direction (S2), one is neutral (S3), and one is negative (S1). Thus, with respect to RQ2, the interpersonal domain displays the most consistently positive pattern (3 out of 3 studies), whereas the cognitive and intrapersonal domains exhibit mixed patterns of positive, neutral, and negative effects, which are explored further in the Discussion section.

Answer to RQ3 – Factors/Approaches Associated with Higher Achievement

RQ3 investigates the learning approaches and contextual factors associated with green skills attainment. Drawing on the codes in the codebook, each study was examined to identify its main factors, the type of quantitative evidence used, and the direction of the association. These findings are summarized in Table 8.

Table 8. Factors/Approaches and Direction of Association by Study

ID	Factor or Approach	Type of Evidence	Direction of Association	Notes
S2	GS-oriented learning module based on the ADDIE model in meat processing technology	Pre-post design with mean scores and N-gain	↑ positive	Mean scores increase from 46.7 to 73.3 with N-gain 0.4 (moderate). The module is rated "highly feasible" by experts.
S5	Internalisation of Islamic values such as faith, environmental ethics, and zero waste practices	Regression and ANOVA linking value indicators to GS outcomes	↑ positive	With n = 562 students, value indicators show statistically significant positive effects ($p < 0.001$) on GS scores.
S3	Green school culture, collaborative learning, and Adiwiyata school environment	Descriptive statistics, ANOVA, and path analysis across CC, IC, iac, and total GS	Mixed: IC ↑, iac ↓	IC benefits from collaborative and culture-related factors. Iac remains low, indicating that attitudes and self-regulation require deeper or longer reinforcement.
S4	Industry expectations and demand for GS among agribusiness employers	Survey of perceived importance and priority indicators	↑ positive demand	GS is consistently rated as important or very important in recruitment. This is a strong external driver, although student GS is not measured.
S1	Teachers' literacy of GS terminology and concepts	Proportions of teachers who are familiar or unfamiliar with GS terms	↓ negative cognitive signal	Limited conceptual understanding among some teachers acts as an upstream constraint for GS-oriented learning.

Table 8 shows that two studies emphasize explicit pedagogical interventions, namely ADDIE model-based learning modules (S2) and the internalization of Islamic values in daily practice (S5). Both display a clear positive relationship with GS scores, through an N-gain of 0.4 in S2 and a significant regression coefficient with $p < 0.001$ in S5. Study S3 links variation in GS scores by domain to the green school context and collaborative learning, with a pattern of relatively higher IC and consistently low IaC. Study S4 adds the perspective of industry stakeholders, who consistently regard GS as an important competency in recruitment, even though

student GS scores were not directly measured. Study S1, in contrast, shows that teachers' limited literacy in GS terminology constitutes a negative signal from the cognitive perspective.

Summary of Effect Direction (Overall)

Based on the overall patterns and domain-level codings presented in the previous section, the distribution of effect directions for each study is summarized in Table 9.

Numerically, four of the five studies (S2, S3, S4, S5) identified at least one factor that was positively related to GS achievement or perceived GS needs, whereas one study (S1) highlighted a negative factor in the form of low teacher literacy. Among the three studies that directly measured students' GS (S2, S3, S5), two (S2 and S5) linked higher GS attainment to structured interventions in the form of instructional modules and value reinforcement, while one study (S3) reported low intrapersonal GS despite a supportive school context. Thus, in response to RQ3, the corpus suggests that GS-oriented learning modules, value reinforcement, and pressure from industry needs emerge as factors associated with stronger GS signals, whereas limitations in teacher literacy function as a constraining factor. This pattern is elaborated further in the Discussion section.

Table 9. Overall Vote Count by Study

Id	Overall Effect Direction	Justification
S1	↓	Limited teacher familiarity with GS concepts and terminology indicates low cognitive GS in part of the sample.
S2	↑	The GS module produces an N-gain of 0.4 and a clear increase in GS-related test scores.
S3	→	Teachers show high GS levels and students low levels with mixed patterns by domain. The study mainly reveals gaps rather than a clear improvement or decline.
S4	↑	Industry practitioners consistently rate GS as important for vocational graduates, signalling strong demand and policy pressure to strengthen GS.
S5	↑	Islamic values and pro-environmental behaviours show statistically significant positive associations with GS outcomes.

Discussion

This study presents a quantitative secondary synthesis of 5 Scopus-indexed empirical articles on green skills in vocational education and technical secondary schools in Indonesia. Using narrative synthesis and vote counting based on effect direction, the analysis focuses on the direction and consistency of findings rather than on combining effect sizes. Through 3 research questions, the results show how the level of green skills differs between teachers and students, how the cognitive, interpersonal, and intrapersonal domains behave differently, and which learning approaches and contextual factors are associated with stronger green skills signals. This focus on competency transformation is in line with discussions on the shift of vocational education and training towards sustainable development in various international contexts (Pavlova & Askerud, 2024). In the context of cross-border public services, the integration of environmental education into transportation systems shows that green skills are not only relevant in classrooms but can also be cultivated through nontraditional learning spaces such as public transport (Masud et al., 2025). In the natural resources sector, the role of green skills in community enterprises in Indonesia confirms that green competencies are an important component of the broader work ecosystem (Suryawan et al., 2024).

In response to RQ1, the synthesis indicates that the maturity of green skills in Indonesian vocational education is still uneven and tends to be higher among teachers than among students. In the multi-school study, average student scores ranged from 2.188 to 2.594, whereas average teacher scores on the same 4-point scale ranged from 2.242 to 2.917. Two of the 3 studies that classified levels placed students' green skills in the low category, and only 1 study reported a moderate improvement with N-gain = 0.4 (↑) when the average test score increased from 46.7 to 73.3 following the implementation of GS-oriented modules. At the same time, a preliminary survey of agricultural vocational school teachers showed that some respondents were unfamiliar with the term "green skills", so from a cognitive perspective the signal that emerged tended to be weak (↓). Overall, this pattern shows that although teachers report higher levels of green skills than students, conceptual literacy about green skills and the ability to translate and assess indicators are still uneven. As a result, the flow of knowledge and green work practices from teachers to students is hindered at the levels of terminology, understanding, and assessment. The gap between system needs and the readiness of education actors is consistent with discussions of green economic opportunities and the need for green skills as a prerequisite for achieving carbon neutrality targets in Indonesia (Erwinsyah, 2021). At the higher education level, analyses of the determinants of students' green skills also indicate that the achievement of green competencies depends strongly on a combination of individual and institutional factors. In line with this, studies on success factors in green human resource

development emphasize that programs which explicitly target green competencies are needed to reduce achievement gaps (Novita et al., 2025).

Answering RQ2, the domain level analysis and the heatmap of effect directions show that green skills do not develop uniformly across all domains. In the cognitive domain (CC), 3 mappable studies show a mixed pattern: S1 is coded as decreasing (↓) because of low terminology literacy among some teachers, S2 is coded as increasing (↑) because the module produced higher scores and N-gain = 0.4, while S3 is coded as neutral (→) because average scores for teachers were high and for students were low, so that the aggregate pattern appears stable. In the interpersonal domain (IC), the pattern is more consistent. Of the 3 relevant studies (S2, S3, S5), all show an increasing direction (↑), so IC receives 3 out of 3 positive signals and no neutral (→) or negative (↓) effects. In contrast, the intrapersonal domain (IaC) shows more obvious vulnerability. Of the 3 studies that can be mapped, 2 studies (S2 and S5) show an increasing direction (↑), while S3 shows a decreasing direction (↓) because intrapersonal scores are low for both teachers and students despite the green school context. These results confirm that the ability to collaborate and communicate (IC) is more easily fostered through collaborative learning and school culture, whereas attitudes, motivation, pro-environmental habits, and self-regulation (IaC) require deeper and more long-term learning experiences.

This imbalance between domains intersects with findings on the influence of a green school based inquiry model on scientific literacy, where the design of learning experiences and the school context play a major role in strengthening cognitive dimensions and higher order thinking skills (Marzuki et al., 2022). Within the ESD framework, the application of inquiry learning models integrated with education for sustainable development has been shown to enhance critical thinking skills and sustainability awareness (Setyaningrum et al., 2023). Students' sustainability awareness and engagement have also been identified as important factors in project based biology learning, confirming the role of interpersonal and intrapersonal domains in the success of project activities. At the same time, studies on the specificity of thinking in chemistry education show that disciplinary reasoning in particular fields of science shapes sensitivity to sustainability issues, especially in cognitive and scientific attitude domains (Islam et al., 2025). Science teachers' perceptions of STEM learning for sustainable development also indicate that cognitive, interpersonal, and intrapersonal elements do not automatically develop in parallel without explicit learning design (A. A. Rahman et al., 2023). In a different scientific context, the relationship between technology, engineering, and maritime education suggests that the field of expertise itself can create new opportunities and challenges for the formation of green competencies (Nasution et al., 2024). The use of digital games to teach green skills in chemistry education further demonstrates that innovative learning environments can integrate cognitive, collaborative, and 21st century skills (Lathwesen & Eilks, 2024).

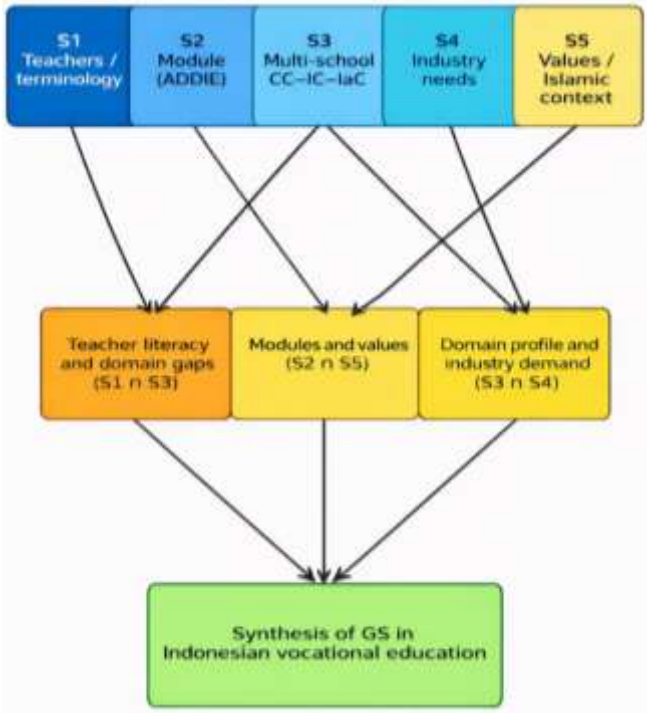

Figure 3. Intersections between research questions

Answering RQ3, the synthesis identifies 3 consistent groups of driving factors associated with higher green skills achievement or with strong signals of green skills needs. First, structured GS-oriented learning modules (S2) emerge as a promising driver of improvement. The ADDIE-based module resulted in an increase in scores from 46.7 to 73.3 with N-gain = 0.4 (↑), in line with the development of green skills modules in design and technology programs that emphasize clear learning sequences and explicit objectives (Riswano, 2023), as well as cross-disciplinary classroom to field approaches that stress direct experience in real work contexts (Bakhri, 2021). On the teaching strategy side, research on learning for sustainable development underlines that explicitly designed strategies to foster sustainable skills and dispositions are essential so that improvements in green skills do not remain sporadic. Second, value-based reinforcement and pro-environmental behavior (S5) show a clear positive association with GS scores. Indicators of faith and environmental ethics have a significant effect ($p < 0.001$) among 562 Islamic vocational school students, which is consistent with evidence that integrating sustainability

values into science learning can increase students' awareness and sensitivity to environmental issues and that linking scientific concepts to real-world issues strengthens the relationship between conceptual understanding and sustainability attitudes. Third, the school context and pressures from the world of work (S3 and S4) act as external supports or constraints. Green school culture and collaborative learning are associated with higher IC profiles even when IaC remains low, while agribusiness actors describe green skills as an important to very important criterion in recruitment. This pattern is consistent with the idea of a Green ASEAN Curriculum, which views green skills as a key element of 21st century work readiness, with the national green economy agenda that requires green competencies to be fulfilled (Erwinsyah, 2021), and with evidence from the forestry sector that green skills are a driver of sustainable business success (Suryawan et al., 2024).

The conceptual intersections between these studies are visualized in Figure 3. The intersection between S1 and S3 highlights the role of teacher literacy in cross-domain profiles. When some teachers are not yet familiar with the key concept of green skills (CC ↓), the gap between teacher and student levels tends to persist, especially in intrapersonal competencies (IaC ↓). The intersection between S2 and S5 shows that a combination of structured modules and internalized values can have a positive effect on both cognitive and noncognitive green skills (CC/IC/IaC ↑). The intersection between S3 and S4 highlights the relationship between school domain profiles and industry expectations, in which the CC–IC–IaC profile for each school can serve as an operational map to align assessment indicators in workshops and industrial placements with signals of green skills needs from agribusiness actors. The importance of the physical school environment as a learning resource is reinforced by findings that green school buildings can "teach" through their design and facilities (Sundar & Ramalingam, 2024). In parallel, the innovation ecosystem surrounding Industry 4.0 adoption suggests a growing need for new competencies that are both technological and sustainable (Matt et al., 2025), while the use of digital games to contextualize green skills illustrates how creative learning environments can support the development of cross-domain competencies (Lathwesen & Eilks, 2024).

Differences in findings across the 5 studies can be understood as consequences of differences in design, focus, and measurement, rather than as direct contradictions. Weak cognitive signals in the teacher terminology survey (CC ↓ in S1) do not contradict the moderate N-gain reported in the module study (CC/IC/IaC ↑ in S2), because the two refer to different populations, instruments, and time horizons. The coexistence of strong interpersonal scores (IC ↑) and low intrapersonal scores (IaC ↓) likewise indicates that collaboration skills are not automatically accompanied by strong self-regulation or pro-environmental habits. This underscores the importance of analyzing green skills at the domain level rather than relying on a single composite score. The need for validated instruments is in line with the emphasis on content validity in the development of innovative work behavior instruments for teachers. Efforts to strengthen vocational teachers' technological competencies also show that pedagogical and technological readiness go hand in hand with the need for green competencies, so that digital literacy and sustainability literacy must be developed together (Latif et al., 2024). In addition, modeling a digital ecosystem for international student licensing suggests that credentialing and competency recognition systems, including green skills, will increasingly rely on interconnected digital infrastructures and will require clear standards and documentation of achievement (Yunanto & Tricahyono, 2025). This synthesis is therefore best understood as a mapping of trends and development priorities, in line with reviews of research trends in reading comprehension and Indonesian language studies (Suyanto et al., 2024), studies of the adaptive dynamics of alternative educational institutions in Java (Fahmi et al., 2025), and bibliometric analyses of green skills research in vocational education.

The implications of this study suggest that mapping the maturity of green skills and the imbalance across domains (CC, IC, IaC) can provide a concrete basis for designing learning modules and teacher development programs that more deliberately strengthen green competencies in vocational schools. Future work should build on these insights through empirical research in vocational education, for example multi-school quasi-experimental studies that test the effectiveness of different green skills interventions and examine the extent to which improvements observed in the classroom actually manifest as green work behaviours during industrial practice and in the early stages of employment.

Conclusion

This study synthesizes five Scopus-indexed empirical studies on green skills (GS) in Indonesian vocational education, focusing on the cognitive, interpersonal, and intrapersonal domains. For RQ1, the results show an uneven maturity of GS, with teachers generally scoring higher than students; the average student score ranged from 2.188 to 2.594, and the teacher score ranged from 2.242 to 2.917 on the same 4-point scale. Two of the three studies that classified GS levels placed students in the low category. For RQ2,

interpersonal competence showed a consistent positive effect, while intrapersonal competence showed a mixed pattern, and cognitive competence showed varying directions. One study showed a moderate increase (N-gain = 0.4) after the implementation of a GS-oriented module. For RQ3, the main factors contributing to GS development included GS-oriented learning modules, value-based reinforcement (especially Islamic values and environmental ethics), and a green school culture. This synthesis highlights the need for further research in Indonesian vocational education to use standard instruments to measure the GS domain, report domain-specific results with reliability statistics, and test value-based modules to see whether GS improvements actually impact observable work behavior in the workplace.

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