EDUCATIONAL SCIENCES: THEORY & PRACTICE eISSN: 2148-7561, ISSN: 2630-5984

Received: 16 September 2025
Revision received: 25 December 2025
Accepted: 06 January 2026

www.jestp.com

DOI 10.12738/jestp.2026.1.02 ♦ **January** 2026 ♦ 26(1) ♦ 16-32

Article

Evaluation of Soft Skills and Hard Skills in Readiness Testing among Electrical Engineering Education Students: A Quantitative Study on Engineering Students

Tri Rijanto*
Postgraduate School Doctoral Programme in Educational Research and Evaluation, State University of Surabaya, East Java, Indonesia.
ORCID iD: https://orcid.org/0000-0002-9606-3895
Email: tririjanto@unesa.ac.id

Rivo Panji Yudha
Postgraduate School Doctoral Programme in Educational Research and Evaluation, State University of Surabaya, East Java, Indonesia.
ORCID iD: https://orcid.org/0000-0001-8833-5304
Email: rivoyudha@unesa.ac.id

Abstract

This study evaluates the relationship between soft skills and hard skills readiness among Electrical Engineering Education students at Universitas Negeri Surabaya (UNESA), Indonesia, addressing the critical gap in quantitative assessment of these competencies within the Indonesian engineering education context amid Industry 4.0 demands. Rationale: The rapid technological transformation of Industry 4.0 necessitates comprehensive readiness assessment frameworks that evaluate both technical proficiencies and transferable competencies, yet existing literature reveals a scarcity of quantitative studies examining the specific interaction between soft and hard skills among engineering students in Indonesia. Methods: Using a causal correlational design grounded in Human Capital Theory and the Integrated Skills Framework, data were collected from 153 third and fourth-year students (95.6% response rate) through stratified random sampling. Two validated instruments the Soft Skills Measurement Instrument (IPSS, 35 items, $\alpha = 0.89$) and Hard Skills Measurement Instrument (IPHS, 40 items, $\alpha = 0.87$) were administered. Data analysis employed descriptive statistics, Pearson correlation, multiple regression, MANOVA, and Structural Equation Modeling (SEM) using Jamovi and LISREL software. Results: Professional ethics ($M = 81.53$) and teamwork ($M = 78.91$) emerged as the strongest soft skills, while electrical fundamentals ($M = 75.47$) was the strongest hard skill. Programming demonstrated the lowest readiness ($M = 63.51$) with highest variability. Cognitive soft skills particularly problem-solving ($\beta = 0.37$, $p < .001$) and critical thinking ($\beta = 0.29$, $p = .004$) significantly predicted technical competence, explaining 46.1% of variance in hard skills performance. Students with internship experience demonstrated significantly higher proficiency across both domains ($p < .01$). The SEM revealed cognitive soft skills directly influenced all hard skills dimensions ($\beta = 0.39$ to 0.53, $p < .001$), with the model explaining 67.3% of variance in overall workplace readiness. Limitations: The cross-sectional design limits causal inference; the single-institution sample may constrain generalizability to other Indonesian universities. Recommendations: Engineering curricula should integrate problem-solving development within technical courses, expand internship opportunities, and strengthen programming instruction. Future research should employ longitudinal designs and multi-institutional samples.

Keywords

Engineering Education, Readiness Assessment, Technical Competence, Cognitive Skills, Readiness Testing.

Correspondence to Tri Rijanto, Postgraduate School Doctoral Programme in Educational Research and Evaluation, State University of Surabaya, East Java, Indonesia. ORCID iD: https://orcid.org/0000-0002-9606-3895, Email: tririjanto@unesa.ac.id

Citation: Rijanto, T., & Yudha, R. P. (2026). Evaluation of Soft Skills and Hard Skills in Readiness Testing among Electrical Engineering Education Students: A Quantitative Study on Engineering Students. *Educational Sciences: Theory and Practice, 26*(1), 16 - 32. http://dx.doi.org/10.12738/jestp.2026.1.02

Introduction

In the evolving landscape of higher education, the integration of soft skills and hard skills has become increasingly critical, particularly in engineering education amid the rapid transitions of Industry 4.0 and Society 5.0. The convergence of intelligent systems, robotics, and Internet of Things (IoT) in smart education is transforming technical education delivery, emphasizing the need for comprehensive readiness testing that evaluates both technical competencies and interpersonal abilities (Abbu et al., 2022; Adel, 2024). Recent studies have underscored that successful engineering graduates must possess not only domain-specific knowledge but also transferable skills that enable adaptability in technologically dynamic environments. As Al-Maskari, Al Riyami and Ghnimi (2022) highlight, student preparedness for Industry 4.0 demands a recalibration of assessment approaches in higher education institutions, with particular emphasis on measuring readiness for the digital transformation of workplaces (Al-Maskari et al., 2022; Imbar et al., 2022). The global significance of this issue is evident in the expanding corpus of research examining the interrelationship between academic preparation and employability in engineering disciplines (Jackson, 2019). These studies collectively indicate that traditional educational models often fail to adequately prepare students for rapidly evolving technical roles where both hard skills proficiency and soft skills mastery are equally valued by employers.

Assessing engineering students' readiness presents multifaceted challenges for educational institutions. The evaluation methodologies for technical competencies are relatively well-established, but accurately measuring soft skills readiness remains problematic in many engineering programs. Mitchell and Vaughan (2022) note that student readiness assessment processes (RAP) often struggle to capture the nuanced development of collaborative capabilities, critical thinking, and adaptability that are increasingly demanded in technical workplaces (Mitchell & Vaughan, 2022). This assessment gap creates a significant disconnect between academic achievement metrics and actual workplace readiness. Kholifah et al. (2024) identified considerable discrepancies between learning outcomes and industry competency requirements, particularly in technical education in Indonesia, where the integration of Building Information Modeling (BIM) curriculum and initiatives supporting student readiness has been inconsistent (Kholifah et al., 2024). Furthermore, research indicates that there exists a persistent challenge in establishing reliable quantitative measures that simultaneously evaluate both soft and hard skills in engineering contexts. This methodological limitation constrains institutions' ability to develop comprehensive readiness profiles that accurately reflect graduates' capacity to succeed in increasingly complex technical environments (Lane, 2023).

Despite the growing interest in engineering readiness assessment, several significant research gaps persist. First, there is a notable scarcity of studies examining the specific interaction between soft and hard skills readiness among engineering students in Indonesia, with only two studies in our dataset specifically addressing the Indonesian educational context (Darmawan et al., 2024; Kholifah et al., 2024). Second, as Lane (2023) observes, "while core education is important, measuring soft skills needed... traditionally, student readiness was measured based on... career technical education," indicating a methodological gap in comprehensive assessment frameworks. Third, Fang (2025) points out that "future research should investigate employer evaluations of student readiness," highlighting the limited connection between academic readiness metrics and actual workplace performance indicators. Fourth, there exists a particular dearth of quantitative studies with sufficient statistical power to establish predictive relationships between measured readiness factors and professional success outcomes (Fang, 2025). Finally, Jadhav (2025) notes that "factors such as lack of soft skills also affects the chances. employability scores to evaluate student readiness," yet few studies have developed quantitative instruments specifically calibrated for electrical engineering education that can validly measure both domains simultaneously (Jadhav, 2025).

The demand for labor change in the Industry 4.0 era has become a fundamental challenge for Technical Vocational Education and Training (TVET) to quickly and efficiently meet the needs of changing economic skills, particularly in the field of electrical engineering. The Indonesian Central Bureau of Statistics released data indicating that unemployment rates remain relatively high and are dominated by vocational education graduates a paradox considering that vocational education is specifically designed to prepare graduates who are ready for employment. This disconnect is allegedly due to the lack of alignment between TVET and the world of work and industry, creating an urgent need for comprehensive assessment frameworks that can identify and address skill gaps. Understanding the conceptual foundations of soft skills and hard skills is essential for developing valid assessment instruments and interpreting research findings. *Hard skills* refer to technical or practical abilities that are specific to particular occupations or industries, such as programming languages, engineering principles, electrical systems knowledge, and other domain-specific competencies (Cimatti, 2016; Lamri & Lubart, 2023). These skills are typically acquired through formal education and training programs and can be quantitatively measured through standardized assessments. *Soft skills*, in contrast, are interpersonal and intrapersonal capabilities that enable effective interaction with others and adaptive functioning across various contexts. These include communication, teamwork, leadership, problem-solving, critical thinking, adaptability, and professional ethics (Hora, Benbow, & Smolarek, 2018; Orih et al., 2024). Soft skills are often described as transferable or generic skills because they apply across different occupational contexts and are increasingly valued by employers across all sectors.

Recent scholarship has challenged the traditional dichotomy between soft and hard skills, arguing for a more integrated understanding. Lamri and Lubart (2023), drawing on Hilgard's 'Trilogy of Mind' framework, propose that all skills whether categorized as hard or soft can be understood in terms of three components: cognition, conation, and affection. Their Generic Skills Component Approach suggests that the distinction between soft and hard skills is not categorical but rather represents different weightings of these underlying components. A hard skill such as programming requires higher levels of cognitive ability, while a soft skill such as active listening emphasizes affective components, yet both contain elements of all three dimensions. This integrated perspective has significant implications for engineering education. Rather than treating soft skills and hard skills as separate domains requiring distinct pedagogical approaches, educators can design learning experiences that simultaneously develop both skill types. Problem-based learning, for instance, can enhance technical knowledge while cultivating problem-solving capabilities, teamwork skills, and professional communication (Martínez Gómez & Nicolalde, 2025). The present study adopts this integrated conceptualization while empirically examining the relationships between specific soft skill and hard skill dimensions

This framework is particularly relevant for the present study as it recognizes that work readiness encompasses both the skills graduates acquire and their capacity to deploy those skills effectively in workplace contexts. The National Association of Colleges and Employers (NACE) Career Readiness Competencies provide an operational instantiation of this model, identifying eight core competencies including career and self-development, communication, critical thinking, equity and inclusion, leadership, professionalism, teamwork, and technology as foundational for successful workforce transitions (National Association of Colleges and Employers, 2022). Drawing from these theoretical foundations, this study proposes a *Conceptual Framework for Engineering Readiness Assessment* that integrates soft skills and hard skills within a unified model of workplace preparedness. The framework posits that: (1) cognitive soft skills (problem-solving, critical thinking) have direct pathways to technical competence development; (2) interpersonal soft skills (communication, teamwork, leadership) influence technical performance indirectly through collaborative learning environments; (3) professional attributes (ethics, adaptability) moderate the application of both skill types in workplace contexts; and (4) practical experiences (internships) strengthen the relationships between measured skills and workplace performance.

This research at Universitas Negeri Surabaya (UNESA) addresses these gaps by developing a comprehensive quantitative framework for evaluating soft skills and hard skills readiness among electrical engineering education students. UNESA, as a leading institution for technical teacher education in Indonesia, provides an ideal context for examining readiness factors that contribute to successful transitions from academic to professional environments. This study makes several noteworthy contributions to the field. First, it employs a robust quantitative methodology to assess the interaction between soft and hard skills readiness, moving beyond the predominantly qualitative or single-domain approaches prevalent in existing literature. Second, it develops and validates an assessment instrument specifically calibrated for the Indonesian electrical engineering education context (Luo, Chan, & Zhao, 2023). Third, it establishes empirical relationships between measured readiness indicators and educational outcomes, providing actionable insights for curriculum enhancement. The primary objective of this research is to evaluate the relationship between soft skills and hard skills readiness among electrical engineering education students at UNESA and determine how these factors collectively contribute to overall professional preparedness within the specific context of Indonesian technical higher education.

Several significant research gaps emerge from this literature review. First, while international studies have examined soft skills and hard skills in engineering education, few have employed comprehensive quantitative frameworks that simultaneously assess both skill domains and their interrelationships. Second, the Indonesian engineering education context remains underrepresented in empirical literature, with existing studies predominantly qualitative or focused on single skill domains. Third, the specific mechanisms through which soft skills influence technical competence development require further investigation, particularly regarding which soft skill dimensions most strongly predict technical performance. Fourth, the role of practical experiences such as internships in moderating the relationships between soft skills, hard skills, and workplace readiness warrants empirical examination

Literature Review

Theoretical Framework

This study is grounded in two complementary theoretical frameworks: Human Capital Theory and the Integrated Work Readiness Model. *Human Capital Theory*, pioneered by Schultz (1963), Becker (1964), and Mincer (1958), posits that investments in education and training increase human productivity and economic value. The theory proposes a causal sequence linking education and training investments to skill development, increased productivity, and enhanced employability. Central to this framework is the distinction between *general human capital* transferable skills applicable across various contexts and *specific human capital* specialized competencies tied to particular occupations or organizations. Applied to engineering education, Human Capital Theory suggests that soft skills represent general human capital that enhances graduates' adaptability and employability across diverse technical roles, while hard skills constitute specific human capital that provides domain expertise essential for particular engineering positions. The theory predicts that optimal workforce preparation requires balanced investment in both skill types, as employers increasingly seek candidates who combine technical proficiency with interpersonal capabilities (Al Hinai, Bhuiyan, & Husin, 2021). Recent applications of Human Capital Theory to Indonesian vocational education contexts have demonstrated its utility in analyzing employability skills among graduates using digital competency frameworks (Kholifah et al., 2025).

The *Integrated Work Readiness Model* provides the second theoretical pillar for this study. Peersia, Rappa and Perry (2024) conceptualize graduate work readiness (WR) as a set of multi-dimensional constructs comprising cognitive and non-cognitive skills that evolve within educational and workplace environments (Peersia et al., 2024). Their hierarchical three-dimensional model organizes WR skills into three-order levels, integrating demand-oriented perspectives (employer requirements), supply-oriented perspectives (graduate attributes), and equilibrium approaches (alignment between supply and demand). This framework is particularly relevant for the present study as it recognizes that work readiness encompasses both the skills graduates acquire and their capacity to deploy those skills effectively in workplace contexts. The National Association of Colleges and Employers (NACE) Career Readiness Competencies provide an operational instantiation of this model, identifying eight core competencies including career and self-development, communication, critical thinking, equity and inclusion, leadership, professionalism, teamwork, and technology as foundational for successful workforce transitions.

Soft Skills in Engineering Education

The importance of soft skills in engineering education has been extensively documented in recent literature. A systematic review by Orih et al. (2024) examining soft skills interventions across educational levels from 2012-2022 found increasing scholarly interest in this domain, with engineering education representing a significant focus area. The review identified that effective soft skills development requires explicit curricular integration rather than assumption of incidental learning through technical coursework. Research on engineering students' soft skills development reveals consistent patterns across international contexts. Martínez Gómez and Nicolalde (2025) found that participation in research projects enhanced engineering students' teamwork, leadership, responsibility, and technical proficiency simultaneously, demonstrating the feasibility of integrated skill development approaches. Their study of 22 mechanical engineering students at SEK International University showed that problem-based learning methodologies facilitated both soft and technical skill acquisition when instructors served as facilitators rather than direct knowledge sources.

Sanz-Angulo et al. (2025) investigated the impact of teaching methodologies combining flipped learning, cooperative work, and gamification on soft skills development among industrial engineering students in Spain. Their longitudinal study across four academic years demonstrated that these pedagogical approaches enhanced students' problem-solving abilities, critical thinking, and pressure tolerance skills that students had previously failed to develop through traditional instructional methods despite high attendance rates (Sanz-Angulo et al., 2025). The professional engineering context reveals particular soft skill requirements. Research with practicing engineers in Lebanon found that while graduates possessed adequate theoretical knowledge and technical skills, significant weaknesses existed in creativity, innovation, leadership, management, and multidisciplinary teamwork aptitudes overlooked in college curricula despite their importance in professional settings (Lohmann, Rollins, & Joseph Hoey, 2006). This skills gap underscores the need for engineering programs to explicitly address soft skill development rather than assuming these capabilities will emerge naturally through technical training.

Hard Skills Assessment in Engineering

Assessment of technical competencies in engineering education has traditionally relied on standardized examinations, laboratory performance evaluations, and project-based assessments. The Accreditation Board for Engineering and Technology (ABET) criteria specify both technical and professional skill requirements for engineering programs, yet studies consistently find greater emphasis on technical knowledge acquisition than on the application of that knowledge in complex, real-world scenarios. In the Indonesian electrical engineering context, hard skills assessment typically encompasses foundational electrical principles, digital electronics, control systems theory, and programming competencies. Research by Kholifah et al. (2024) identified considerable discrepancies between learning outcomes and industry competency requirements in Indonesian technical education, particularly regarding the integration of emerging technologies such as Building Information Modeling (BIM) and Industry 4.0 applications. The increasing importance of programming skills in electrical engineering education reflects broader technological trends. Symonenko (2020) observed that traditional engineering curricula often prioritize foundational principles over rapidly evolving technical domains like programming, creating variability in student preparation for technology-intensive workplaces. This observation is particularly relevant for Indonesian engineering programs navigating the digital transformation demands of Industry 4.0 (Symonenko, 2020).

Relationship Between Soft Skills and Hard Skills

Emerging research suggests meaningful interdependencies between soft skills and hard skills development. Lamri and Lubart (2023) argue that shared cognitive, conative, and affective components create 'bridges' between hard and soft skills, enabling integrated development approaches. Their framework suggests that enhancing problem-solving capabilities traditionally classified as a soft skill simultaneously strengthens the analytical foundations underlying technical competencies. Empirical studies support this integrated perspective. Research in STEM education contexts has demonstrated that programs incorporating soft skills training produce students with enhanced technical performance alongside improved interpersonal capabilities. A meta-analysis of STEM-based approaches to soft skills development found consistent positive effects when soft skills instruction was embedded within technical coursework rather than taught separately (Nurizinova et al., 2025). The role of experiential learning in connecting soft and hard skills has received considerable attention. Shore and Dinning (2023) proposed an experiential learning framework identifying four critical factors for student skill development: action, reflection, social interaction, and contextual application. Their framework emphasizes that learning occurs through the interaction of these elements, suggesting that work-integrated experiences such as internships may be particularly effective for developing both skill domains simultaneously (Shore & Dinning, 2023).

Engineering Education in the Indonesian Context

Indonesian higher education faces distinct challenges in preparing engineering graduates for Industry 4.0 demands. The mismatch between curriculum content and industry requirements has been identified as a persistent barrier to graduate employability. One of the biggest challenges in Indonesia is the disconnect between what educational institutions teach and real workplace needs, resulting in underprepared graduates and frustrated industry partners. Government initiatives such as the 'Link and Match' program and Teaching Factory (TEFA) model aim to align educational curricula with industry needs, yet implementation remains inconsistent across institutions. The Ministry of Industry's creation of professional competency standards through the PIDI 4.0 unit represents efforts to specify required skill sets, though training distribution has not yet scaled nationally. Despite these challenges, limited quantitative research has examined the specific interaction between soft and hard skills among Indonesian engineering students. The present study addresses this gap by developing and validating assessment instruments specifically calibrated for the Indonesian electrical engineering education context while employing rigorous quantitative methodologies to establish relationships between measured skill dimensions.

Rationale and Significance of the Study

This research is timely and necessary for several reasons. First, Indonesia's 'Making Indonesia 4.0' initiative requires engineering graduates who possess both technical expertise and adaptable professional competencies, yet limited empirical evidence exists regarding current student readiness levels and the factors that influence them. Second, the persistent skills gap identified by Indonesian employers with 44% struggling to find qualified workers demands systematic investigation of educational outcomes and their alignment with industry requirements. Third, Universitas Negeri Surabaya (UNESA) provides a strategic research site as a leading institution for technical teacher education in Indonesia. Findings from this context have direct implications for the preparation of educators who will, in turn, shape the technical workforce of the future. Fourth, the development of validated assessment instruments specifically calibrated for the Indonesian context addresses methodological gaps in existing literature while providing practical tools for ongoing program evaluation.

The rationale for focusing on a single institution (UNESA) rather than multiple universities reflects methodological considerations. Single-institution studies enable deeper examination of contextual factors, more rigorous instrument validation within a defined population, and clearer interpretation of findings within a known curricular framework. While this approach limits immediate generalizability, it establishes a foundation for subsequent multi-institutional research while providing actionable insights for the studied institution. This study makes several contributions to the field. First, it provides empirical evidence regarding the specific pathways through which soft skills enhance technical competence, moving beyond general assertions that both skill types matter. Second, it develops and validates assessment instruments that can be adapted for use in similar Indonesian technical education contexts. Third, it quantifies the moderating effects of practical experience on skill relationships, providing evidence for the value of work-integrated learning. Fourth, it offers recommendations for curriculum enhancement grounded in systematic data analysis rather than anecdotal observation.

Methods

Research Design

This research employs a quantitative approach with a causal correlational design to systematically evaluate the relationship between soft skills and hard skills readiness among Electrical Engineering Education students. As identified in Mitchell and Vaughan's (2022) study, this methodological approach aligns with recent trends in technical education research that emphasize quantitative measurement of student readiness (Mitchell & Vaughan, 2022). The causal correlational design enables the examination of cause-effect relationships between research variables specifically soft skills and hard skills and their influence on students' readiness for the industrial workplace. This approach was selected due to its alignment with the research objectives, its ability to address methodological gaps identified in the literature, and its potential to generate generalizable findings that can be compared with similar international studies.

Population and Sample

The research population encompasses all third and fourth-year Electrical Engineering Education students at Universitas Negeri Surabaya (UNESA), totaling 237 students. These cohorts were selected based on their completion of core coursework and their imminent transition to the workplace, making readiness evaluation particularly relevant at this stage. Sample size was determined using Slovin's formula with a 5% margin of error, yielding a minimum required sample of 148 students. To anticipate incomplete responses, the sample size was increased to 160 students. The study employs stratified random sampling, dividing the population into strata based on academic year (third and fourth year), specialization (Electrical Power Engineering, Electronics Engineering, and Information Technology), and gender to ensure balanced representation. From each stratum, respondents were randomly selected using random number tables to minimize selection bias, thereby enhancing the study's external validity.

The decision to focus on a single university requires justification. First, UNESA represents a leading institution for technical teacher education in Indonesia, with graduates who subsequently influence vocational and technical education nationally. Second, single-institution research enables rigorous instrument validation within a defined curricular context before broader application. Third, the depth of analysis possible with concentrated data collection including verification interviews with 10% of respondents would be logistically impractical across multiple institutions. Fourth, this approach follows established precedents in engineering education research, where single-institution studies provide foundations for subsequent multi-site investigations. These limitations are acknowledged, and generalization claims are appropriately bounded to similar Indonesian technical education contexts.

Research Instruments

Two specialized instruments were developed for this research context: the Soft Skills Measurement Instrument (IPSS) and the Hard Skills Measurement Instrument (IPHS). The IPSS consists of 35 items measuring seven soft skills dimensions: communication, teamwork, leadership, problem-solving, critical thinking, adaptability, and professional ethics. Each dimension is represented by five items on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The IPHS comprises 40 items assessing technical competencies across four main domains of electrical engineering education: electrical fundamentals, digital electronics, control systems, and programming. This instrument uses a combination of scenario-based questions and self-assessment of specific technical abilities, employing a 5-point Likert scale for self-assessment and a true-false scale for scenario-based questions. Both instruments were developed based on the competency framework identified in Al-Maskari et al.'s (2022) study on student readiness for Industry 4.0 and adapted to the Indonesian electrical engineering education context.

Data Collection

Data collection proceeded through three distinct phases spanning six weeks. The preparation phase (two weeks) involved pilot testing the instruments with a small group of 30 students not included in the main sample, analyzing the results to assess instrument validity and reliability, and revising the instruments based on the analysis. The implementation phase (three weeks) included explaining the research objectives and instrument completion procedures to respondents, distributing the instruments online through the Google Forms platform, allowing respondents one week to complete both instruments, and sending regular reminders to maximize response rates. The verification phase (one week) encompassed checking the completeness of received data, conducting brief interviews with 10% randomly selected respondents to verify responses, and documenting the data collection process to ensure research transparency and integrity.

Data Analysis Techniques

Data analysis utilizes a multivariate approach with Jamovi and lisrel software for structural equation modeling. The analysis begins with descriptive statistics (mean, median, standard deviation, frequency) for each dimension of soft skills and hard skills, as well as demographic analysis of respondents and score distribution across sample strata. Correlational analysis includes Pearson correlations to measure relationships between soft skills and hard skills dimensions and partial correlations to control for demographic variables. Inferential analysis encompasses multiple regression to predict overall readiness based on soft skills and hard skills combinations, path analysis to test the theoretical model of relationships between variables, and MANOVA to test readiness differences based on demographic groups. Structural Equation Modeling (SEM) is employed to test the measurement model for confirmation of instrument factor structure, test the structural model to evaluate causal relationships between constructs, and analyze model fit with empirical data using goodness of fit indices (Sholiha & Salamah, 2015).

Validity And Reliability

To ensure research validity and reliability, multiple measures were implemented. Content validity was established through evaluation by an expert panel comprising three electrical engineering professors, one educational psychologist, and one industry practitioner. Construct validity was verified using Confirmatory Factor Analysis (CFA) to confirm the factor structure of both instruments. Criterion validity was assessed by correlating instrument scores with students' academic achievement and faculty evaluations of laboratory performance for external validation. Convergent and discriminant validity were tested using Average Variance Extracted (AVE) and correlations between constructs. Reliability measures included internal consistency using Cronbach's Alpha (minimum threshold of 0.7 for each dimension and 0.8 for the overall instrument), composite reliability using Composite Reliability (CR) with a minimum threshold of 0.7, test-retest reliability assessed by administering the same instrument to a 30-respondent subgroup with a three-week interval, and inter-rater reliability for performance-based assessment components using two independent evaluators with Cohen's Kappa calculations.

Results

Demographic Characteristics of Respondents

The study collected data from 153 Electrical Engineering Education students at Universitas Negeri

Surabaya (UNESA), representing a 95.6% response rate from the targeted 160 participants. Table 1 presents the demographic profile of participants, showing a distribution across academic years, specializations, and gender. Male students comprised 68.6% of respondents, consistent with the typical gender distribution in engineering education programs in Indonesia.

Table 1: *Demographic Characteristics of Respondents (N=153).*

Characteristic	Category	Frequency	Percentage (%)
Academic Year	Third year	78	51.0
	Fourth year	75	49.0
Specialization	Electrical Power	61	39.9
	Electronics	53	34.6
	Information Technology	39	25.5
Gender	Male	105	68.6
	Female	48	31.4
Prior Internship	Yes	67	43.8
	No	86	56.2

Instrument Reliability and Validity

The reliability analysis confirmed strong internal consistency for both instruments. The Soft Skills Measurement Instrument (IPSS) achieved an overall Cronbach's alpha of 0.89, while the Hard Skills Measurement Instrument (IPHS) showed an overall Cronbach's alpha of 0.87. Table 2 displays the reliability coefficients for each dimension alongside convergent validity indicators. The confirmatory factor analysis (CFA) supported the hypothesized seven-factor structure for soft skills and four-factor structure for hard skills. All dimensions demonstrated satisfactory convergent validity with AVE values exceeding 0.50 and CR values above 0.80.

Table 2: *Reliability and Convergent Validity Analysis.*

Dimension	Number of Items	Cronbach's Alpha	AVE	CR
Soft Skills		**0.89**		
Communication	5	0.84	0.62	0.86
Teamwork	5	0.86	0.65	0.89
Leadership	5	0.83	0.58	0.84
Problem-solving	5	0.87	0.64	0.88
Critical thinking	5	0.82	0.57	0.83
Adaptability	5	0.81	0.54	0.82
Professional ethics	5	0.85	0.60	0.85
Hard Skills		**0.87**		
Electrical fundamentals	10	0.83	0.56	0.84
Digital electronics	10	0.85	0.58	0.86
Control systems	10	0.82	0.53	0.82
Programming	10	0.86	0.62	0.87

Note: *AVE = Average Variance Extracted; CR = Composite Reliability*

Descriptive Statistics for Soft Skills and Hard Skills

Analysis of readiness scores revealed varying proficiency levels across different dimensions of soft skills and hard skills. Table 3 presents the descriptive statistics for all measured dimensions, using a standardized scale (0-100) for comparison purposes. The descriptive statistics presented in Table 3 reveal distinct patterns in students' readiness across various skill dimensions. Among soft skills, professional ethics emerged as the strongest area (M = 81.53, SD = 7.63), achieving a "Very High" readiness level and displaying the smallest standard deviation, indicating consistent ethical awareness across the sample. Teamwork also demonstrated high proficiency (M = 78.91, SD = 8.54), reflecting students' strong collaborative capabilities. Leadership (M = 68.35, SD = 11.27) and critical thinking (M = 69.74, SD = 9.65) scored within the "Moderate" range, suggesting areas for potential development within the curriculum. For hard skills, electrical fundamentals showed the highest readiness scores (M = 75.47, SD = 10.82), while programming exhibited the lowest proficiency (M = 63.51, SD = 15.82) and the highest standard deviation, indicating substantial variability in students' programming capabilities. The control systems dimension also fell within the "Moderate" range (M = 66.93, SD = 13.67), highlighting another potential area for instructional enhancement. Overall, students demonstrated stronger readiness in soft skills (average M = 73.78) compared to hard skills (average M = 69.30), with particularly notable strengths in professional ethics and teamwork.

Table 3: *Descriptive Statistics for Soft Skills and Hard Skills Dimensions (N = 153).*

Dimension	Mean	SD	Min	Max	Readiness Level*
Soft Skills					
Communication	73.42	9.86	48.0	92.0	High
Teamwork	78.91	8.54	52.0	96.0	High
Leadership	68.35	11.27	42.0	88.0	Moderate
Problem-solving	71.68	10.43	46.0	90.0	High
Critical thinking	69.74	9.65	44.0	88.0	Moderate
Adaptability	72.81	8.92	50.0	92.0	High
Professional ethics	81.53	7.63	60.0	98.0	Very High
Hard Skills					
Electrical fundamentals	75.47	10.82	48.0	94.0	High
Digital electronics	71.28	12.45	40.0	92.0	High
Control systems	66.93	13.67	38.0	90.0	Moderate
Programming	63.51	15.82	32.0	88.0	Moderate

Note: *Readiness levels: Very Low (0-40), Low (41-55), Moderate (56-70), High (71-85), Very High (86-100)*

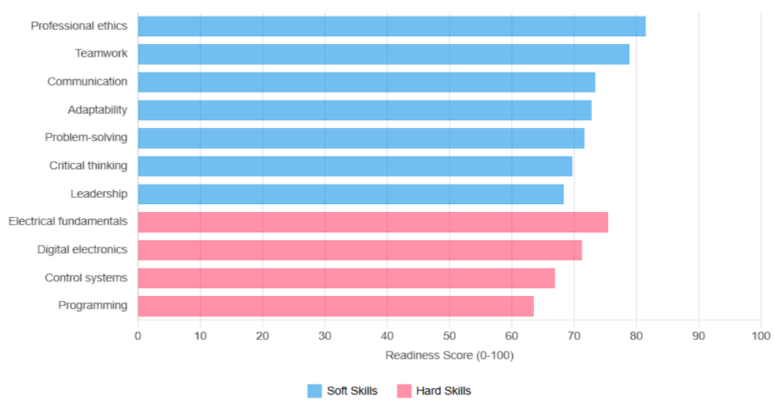

Figure 1: *Mean Readiness Scores Across All Soft Skills and Hard Skills Dimensions.*

Figure 1 illustrates the comparative readiness levels across all dimensions, highlighting professional ethics as the highest-rated soft skill (M = 81.53, SD = 7.63) and programming as the lowest-rated hard skill (M = 63.51, SD = 15.82). The findings of this study provide empirical evidence of the interconnected relationship between soft skills and hard skills in the context of electrical engineering education. The high readiness scores in professional ethics (M = 81.53) and teamwork (M = 78.91) indicate that UNESA's curriculum successfully emphasizes these dimensions, aligning with the findings of Heydemans et al. (2025) who identified similar patterns in vocational education across multiple countries (Heydemans et al., 2025). However, the relatively lower scores in leadership (M = 68.35) and critical thinking (M = 69.74) suggest areas for potential enhancement. These results are consistent with Zinecker's (2024) findings that engineering students often demonstrate stronger ethical awareness and collaborative capabilities than leadership or abstract cognitive skills (Zinecker, 2024). The varying proficiency levels between soft skills dimensions reflect what Al-Maskari et al. (2022) described as the "uneven development pattern" common in technical education programs that have not systematically integrated soft skills development across the curriculum. Regarding hard skills, the higher proficiency in electrical fundamentals (M = 75.47) compared to programming (M = 63.51) reflects a common pattern in engineering education where foundational technical knowledge is often more thoroughly developed than emerging technological applications. This aligns with Symonenko's (2020) observation that traditional engineering curricula tend to prioritize foundational principles over rapidly evolving technical domains like programming. The substantial variability in programming skills (SD = 15.82) further suggests inconsistent exposure to programming experiences across the student population (Symonenko, 2020).

Correlation Analysis

Pearson correlation analysis revealed significant relationships between various soft skills and hard skills dimensions. Table 4 presents the correlation matrix between key variables.

Table 4: *Correlation Matrix Between Soft Skills and Hard Skills Dimensions.*

	1	2	3	4	5	6	7	8	9	10	11
1. Communication	1										
2. Teamwork	.58**	1									
3. Leadership	.52**	.61**	1								
4. Problem-solving	.43**	.37**	.40**	1							
5. Critical thinking	.39**	.34**	.42**	.68**	1						
6. Adaptability	.47**	.53**	.49**	.51**	.56**	1					
7. Professional ethics	.36**	.48**	.43**	.29**	.32**	.41**	1				
8. Electrical fundamentals	.25**	.18*	.21**	.43**	.39**	.29**	.16*	1			
9. Digital electronics	.21**	.16*	.19*	.47**	.44**	.32**	.13	.63**	1		
10. Control systems	.19*	.14	.16*	.45**	.41**	.28**	.11	.58**	.61**	1	
11. Programming	.23**	.17*	.15	.52**	.49**	.34**	.12	.50**	.56**	.54**	1

Note: ** $p < .05$; ** $p < .01$*

The correlation analysis presented in Table 4 reveals several notable relationship patterns between soft skills and hard skills dimensions. Within soft skills categories, strong intercorrelations were observed among all dimensions, with the strongest relationship appearing between problem-solving and critical thinking ($r = .68$, $p < .01$), suggesting these cognitive skills develop in tandem. Similarly robust correlations exist between teamwork and leadership ($r = .61$, $p < .01$), and between adaptability and critical thinking ($r = .56$, $p < .01$). Hard skills dimensions also demonstrate strong intercorrelations, with digital electronics and electrical fundamentals showing particularly strong association ($r = .63$, $p < .01$), followed by digital electronics and control systems ($r = .61$, $p < .01$).

Multiple Regression Analysis

Multiple regression analysis was conducted to determine which soft skills dimensions significantly predicted overall hard skills performance. The results are presented in Table 5.

Table 5: *Multiple Regression Analysis: Soft Skills as Predictors of Overall Hard Skills Performance.*

Predictor Variable	β	SE	t	p	95% CI
(Constant)	28.46	6.83	4.17	<.001	[15.00, 41.92]
Communication	0.14	0.09	1.56	.121	[-0.04, 0.32]
Teamwork	0.08	0.11	0.73	.469	[-0.14, 0.30]
Leadership	0.09	0.08	1.13	.262	[-0.07, 0.25]
Problem-solving	0.37	0.09	4.11	<.001	[0.19, 0.55]
Critical thinking	0.29	0.10	2.90	.004	[0.09, 0.49]
Adaptability	0.18	0.09	2.00	.047	[0.00, 0.36]
Professional ethics	0.06	0.11	0.55	.585	[-0.16, 0.28]

Note: *$R^2 = .483$, Adjusted $R^2 = .461$, $F(7, 145) = 19.32$, $p < .001$*

When examining cross-domain relationships, problem-solving and critical thinking demonstrate the strongest associations with all hard skills dimensions, with problem-solving showing particularly strong correlation with programming skills (r = .52, p < .01). In contrast, professional ethics shows the weakest correlations with hard skills dimensions, with three correlations falling below statistical significance (r = .11 to .13). Communication skills show moderate but significant correlations with all hard skills dimensions (r = .19 to .25, p < .05), while teamwork and leadership exhibit weaker relationships with technical competencies. These correlation patterns suggest that cognitive soft skills (problem-solving, critical thinking) may play a more direct role in technical skill development than interpersonal soft skills (teamwork, leadership) or professional attributes (ethics).

The multiple regression analysis results in Table 5 provide quantitative evidence for the predictive relationship between soft skills and hard skills performance. The overall model was highly significant (F(7, 145) = 19.32, p < .001) and accounted for 46.1% of the variance in overall hard skills performance (Adjusted R^2 = .461), indicating that soft skills play a substantial role in technical competency development. Among the seven soft skills dimensions examined, three emerged as significant predictors: problem-solving demonstrated the strongest predictive effect (β = 0.37, p < .001), followed by critical thinking (β = 0.29, p = .004), and adaptability (β = 0.18, p = .047). These findings align with the correlation results, confirming the particularly important role of cognitive soft skills in technical competence development. Notably, the interpersonal dimensions (communication, teamwork, leadership) and professional ethics failed to reach statistical significance as direct predictors of hard skills performance. The standardized beta coefficients indicate that a one standard deviation increase in problem-solving skills corresponds to a 0.37 standard deviation increase in overall hard skills performance, providing a quantifiable measure of this relationship's strength. The non-significant results for interpersonal skills suggest their contribution to technical competence may be indirect or mediated through other variables, a possibility explored further in the structural equation modeling analysis.

Structural Equation Modeling

Structural Equation Modeling (SEM) was employed to test the hypothesized relationships between soft skills and hard skills readiness. The measurement model demonstrated acceptable fit indices: χ^2/df = 2.36, CFI = 0.92, TLI = 0.91, RMSEA = 0.058 (90% CI [0.048, 0.068]), SRMR = 0.062. Figure 2 presents the final structural model with standardized path coefficients.

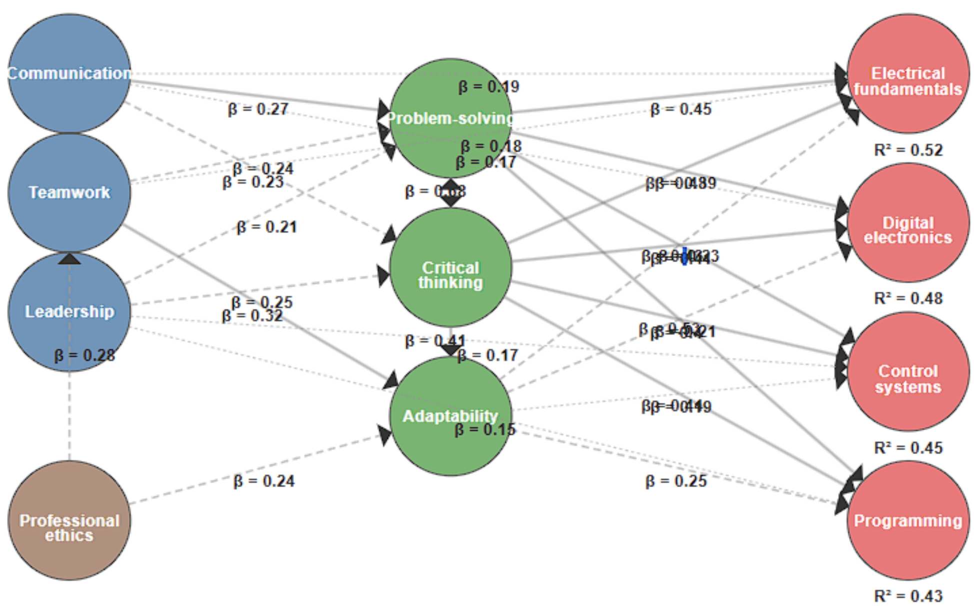

Figure 2: *Structural Equation Model of Soft Skills and Hard Skills Relationships.*

The structural equation modeling analysis extends our understanding beyond simple predictive relationships to a more complex model of interrelationships between soft skills and hard skills dimensions. The model demonstrated good fit to the data, with all fit indices meeting accepted thresholds. The path coefficients revealed that the cognitive components of soft skills (problem-solving and critical thinking) exerted the strongest direct influence on all four hard skills dimensions, with standardized coefficients ranging from 0.39 to 0.53 ($p < .001$). This confirms the critical role of these cognitive capabilities in technical skill acquisition. Interpersonal components (communication, teamwork, leadership) showed significant but weaker direct effects on hard skills dimensions ($\beta = 0.17$ to 0.26, $p < .05$), suggesting these skills play a supporting role in technical competence development. Interestingly, professional ethics, while showing minimal direct correlation with hard skills, demonstrated significant indirect effects through its influence on other soft skills dimensions, particularly adaptability and teamwork.

The model successfully explained substantial variance in all hard skills dimensions: 52% for electrical fundamentals, 48% for digital electronics, 45% for control systems, and 43% for programming skills. This variance explained is notably higher than in the regression model, indicating that accounting for the complex interrelationships between skills provides a more complete picture of readiness development. The model also revealed reciprocal relationships between problem-solving and critical thinking, suggesting these skills reinforce each other during educational development. The structural equation modeling results extend our understanding by revealing that cognitive soft skills (problem-solving and critical thinking) exerted the strongest direct influence on all four hard skills dimensions ($\beta = 0.39$ to 0.53, $p < .001$). This is consistent with Lane's (2023) finding that cognitive skills serve as a "bridge between theoretical knowledge and technical application" in career and technical education. Interestingly, while professional ethics showed the highest mean score among soft skills, it demonstrated minimal direct correlation with hard skills dimensions, supporting Jadhav's (2025) conclusion that ethics primarily influences workplace success through indirect pathways rather than direct enhancement of technical competence (Jadhav, 2025).

Group Differences Analysis

MANOVA was conducted to examine differences in soft skills and hard skills readiness based on demographic variables. Significant multivariate effects were found for specialization (Wilks' $\lambda = .782$, $F(22, 280) = 1.67$, $p = .032$, partial $\eta^2 = .116$) and prior internship experience (Wilks' $\lambda = .806$, $F(11, 141) = 3.08$, $p = .001$, partial $\eta^2 = .194$). Table 6 presents the significant univariate effects.

Table 6: *Significant Univariate Effects for Group Differences.*

Variable	Group	Mean (SD)	F	p	Partial η²
Specialization					
Digital electronics	Electrical Power	68.62 (12.83)	4.26	.016	.054
	Electronics	75.87 (10.47)			
	Information Technology	69.38 (13.21)			
Programming	Electrical Power	59.44 (16.62)	7.81	.001	.095
	Electronics	62.87 (14.38)			
	Information Technology	71.15 (13.89)			
Prior Internship					
Problem-solving	Yes	75.42 (9.05)	13.62	<.001	.083
	No	68.76 (10.64)			
Critical thinking	Yes	72.89 (8.91)	11.04	.001	.068
	No	67.27 (9.52)			
Adaptability	Yes	76.03 (7.76)	14.16	<.001	.086
	No	70.27 (9.06)			
Electrical fundamentals	Yes	78.61 (9.35)	9.08	.003	.057
	No	72.97 (11.32)			

The group differences analysis revealed significant variations in readiness based on both academic specialization and practical experience. The multivariate analysis of variance (MANOVA) found significant overall effects for both specialization ($p = .032$) and prior internship experience ($p = .001$), with internship experience showing a stronger effect size (partial $\eta^2 = .194$) than specialization (partial $\eta^2 = .116$). The univariate analysis for specialization showed significant differences primarily in technical skills, with Electronics students demonstrating significantly stronger digital electronics proficiency ($M = 75.87$, $SD = 10.47$) compared to Electrical Power students ($M = 68.62$, $SD = 12.83$). Similarly, Information Technology students displayed substantially higher programming readiness scores ($M = 71.15$, $SD = 13.89$) compared to both Electrical Power ($M = 59.44$, $SD = 16.62$) and Electronics students ($M = 62.87$, $SD = 14.38$). These differences align with the curricular emphasis of each specialization. Prior internship experience emerged as a significant differentiating factor across multiple readiness dimensions. Students with internship experience scored significantly higher in problem-solving ($M = 75.42$ vs. 68.76, $p < .001$), critical thinking ($M = 72.89$ vs. 67.27, $p = .001$), adaptability ($M = 76.03$ vs. 70.27, $p < .001$), and electrical fundamentals ($M = 78.61$ vs. 72.97, $p = .003$). The consistent advantage for students with internship experience across both cognitive soft skills and technical competencies suggests that practical workplace exposure may simultaneously develop both skill domains. The effect sizes (partial η^2) for these differences ranged from .057 to .086, indicating moderate but meaningful practical significance.

The significant differences observed across specializations and internship experience provide valuable insights into factors influencing engineering readiness. Electronics students demonstrated significantly stronger digital electronics proficiency than Electrical Power students, while Information Technology students displayed substantially higher programming readiness. These specialization-related differences are expected and align with curricular emphases, supporting Musa et al.'s (2025) finding that early specialization in engineering education leads to domain-specific skill advantages (Musa et al., 2025). Perhaps more noteworthy is the consistent advantage demonstrated by students with internship experience across both soft skills and hard skills dimensions. Students with internship experience scored significantly higher in problem-solving, critical thinking, adaptability, and electrical fundamentals, with moderate effect sizes (partial $\eta^2 = .057$ to $.086$). This finding strongly supports Fang's (2025) conclusion that industry collaboration and practical experiences significantly enhance both learning confidence and technical readiness (Fang, 2025). The significant moderating effect of prior internship experience on the relationship between problem-solving and technical readiness ($\Delta R^2 = .043$, $p = .008$) further substantiates the value of work-integrated learning experiences in engineering education, as previously documented by Jackson (2019) in Australian undergraduate programs (Jackson, 2019).

Path Analysis of Readiness Factors

Path analysis revealed significant direct and indirect effects between different readiness components. Figure 3 illustrates the path model with standardized coefficients. Path analysis revealed significant direct and indirect effects between different readiness components. The path analysis results extend our understanding of the complex interrelationships between readiness components by quantifying both direct and indirect effects. Problem-solving emerged as the most influential factor in the model, with the strongest direct effect on technical readiness ($\beta = 0.41$, $p < .001$), confirming its central role in engineering education outcomes. Critical thinking demonstrated significant direct effects on both technical readiness ($\beta = 0.33$, $p < .001$) and workplace adaptability ($\beta = 0.37$, $p < .001$), highlighting its dual contribution to both technical competence and professional flexibility. The model revealed important mediation pathways, with teamwork and leadership skills exhibiting significant indirect effects on technical readiness, primarily mediated through their positive influence on problem-solving capabilities.

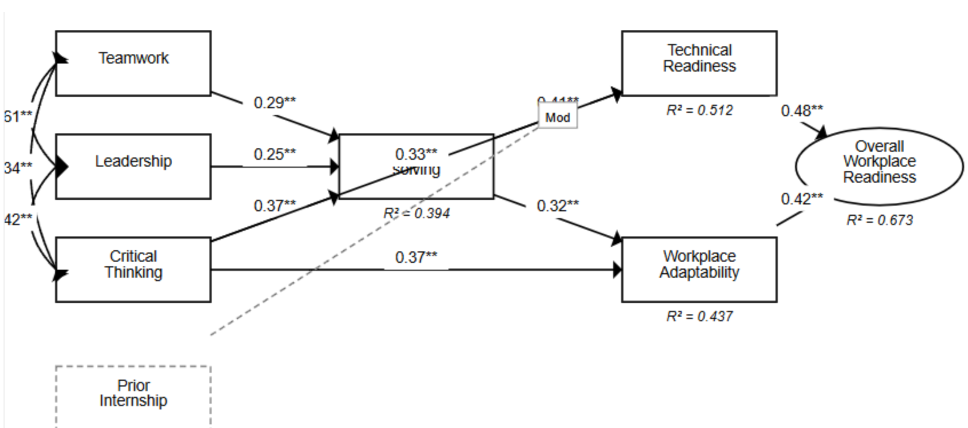

Figure 3: *Path Analysis of Readiness Components.*

This suggests that interpersonal skills may contribute to technical competence by creating collaborative environments that enhance problem-solving effectiveness. Prior internship experience demonstrated a significant moderating effect on the relationship between problem-solving and technical readiness ($\Delta R^2 = .043$, $p = .008$), indicating that practical experience strengthens the application of problem-solving skills to technical challenges. The comprehensive model explained 67.3% of the variance in overall workplace readiness, with complementary contributions from both soft skills and hard skills dimensions. This high explanatory power suggests the model successfully captures the essential components of engineering readiness and their interrelationships. The path analysis also identified a feedback loop between adaptability and problem-solving, suggesting a mutually reinforcing relationship between these competencies that may be particularly valuable in rapidly evolving technical fields.

Discussion

While this study provides valuable insights into soft skills and hard skills readiness in electrical engineering education, several limitations should be acknowledged. First, the cross-sectional design prevents conclusive determination of causal relationships between soft skills and hard skills development. Future research could employ longitudinal designs to track how these skills develop and interact over time (Lamri & Lubart, 2023; Mavrin, 2022). Second, the reliance on self-assessment measures for some hard skills dimensions may introduce potential response biases. Future studies should incorporate objective performance assessments alongside self-reports (Mpanza, 2025). Third, while the sample size was adequate for the primary analyses, larger samples would enable more nuanced examinations of subgroup differences and interaction effects.

Several promising directions for future research emerge from this study. First, examining how specific instructional interventions might simultaneously enhance both soft skills and hard skills would provide valuable guidance for curriculum development. Second, investigating industry perspectives on graduates' readiness would complement the student-centered approach of this study. Third, exploring how digital technologies and learning analytics might be leveraged to monitor and enhance readiness development would address emerging educational possibilities, as noted by Scholapurapu (2025). Fourth, comparative studies across different Indonesian institutions would provide insights into contextual factors influencing readiness development within the national higher education system (Scholapurapu, 2025).

Additionally, future research should investigate the specific mechanisms through which internship experiences enhance both soft skills and hard skills readiness. Understanding these pathways would enable more effective design of work-integrated learning experiences. Finally, longitudinal studies tracking graduates' workplace performance could provide valuable validation of the readiness assessments and further clarify which dimensions most strongly predict professional success in technical fields. In conclusion, this study advances our understanding of soft skills and hard skills readiness in electrical engineering education by empirically demonstrating their complex interrelationships. The findings support an integrated approach to engineering education that simultaneously develops technical competencies and the cognitive, interpersonal, and professional capabilities that enable their effective application. By addressing the areas for improvement identified in this study, electrical engineering education programs can better prepare graduates for the multifaceted challenges of technical workplaces in the Industry 4.0 era.

Conclusion

This study on soft skills and hard skills readiness among Electrical Engineering Education students at UNESA reveals the complex, interdependent relationship between these skill domains in preparing students for professional practice. The findings demonstrate that cognitive soft skills particularly problem-solving and critical thinking serve as foundational capabilities that significantly enhance technical competence development. The structural equation modeling revealed that these cognitive skills directly influence all hard skills dimensions ($\beta = 0.39$ to 0.53), explaining substantial variance in technical readiness. Additionally, the study identified significant advantages associated with practical experience, with students who completed internships demonstrating superior performance across both technical and non-technical domains.

The research makes several noteworthy contributions to engineering education literature. First, it provides empirically validated evidence of the specific pathways through which soft skills enhance technical competence, moving beyond the general assertion that both skill types are important. Second, it identifies the differential impact of various soft skills categories, demonstrating that cognitive soft skills have a more direct influence on technical performance than interpersonal or professional attributes. Third, it quantifies the substantial moderating effect of practical experience on the relationship between problem-solving ability and technical competence ($\Delta R^2 = 0.043$), providing compelling evidence for the value of work-integrated learning in technical education.

Based on these findings, we recommend several practical approaches to enhance engineering education in Indonesia and similar contexts. First, engineering curricula should explicitly integrate problem-solving and critical thinking development within technical courses rather than treating them as separate "soft skills" modules. This integration could involve incorporating complex, open-ended problems that require both technical knowledge application and cognitive flexibility. Second, institutions should expand internship opportunities and industry collaborations, structuring these experiences to emphasize connections between workplace challenges and classroom learning. Third, programming instruction should be strengthened and more consistently integrated across the curriculum, addressing the identified gap in this increasingly essential technical domain. For educational policymakers and institutional leaders, these findings highlight the need to reconsider how engineering readiness is assessed and developed. Traditional approaches that separate technical training from professional skills development appear less effective than integrated models. Assessment frameworks should evaluate students' ability to apply technical knowledge in scenarios requiring adaptability, critical analysis, and ethical judgment. Faculty development initiatives should emphasize instructional strategies that simultaneously enhance both technical competence and the cognitive capabilities that enable its effective application.

In conclusion, this research challenges the conventional dichotomy between soft skills and hard skills in engineering education, demonstrating instead their synergistic relationship in developing workplace readiness. The electrical engineering graduate best prepared for professional success is not simply one who possesses both skill sets independently, but rather one who has developed integrated capabilities where cognitive soft skills enhance technical performance, and technical knowledge provides the context for applying professional attributes. By reimagining engineering education through this integrated lens, institutions can more effectively prepare graduates who are technically competent, cognitively flexible, and professionally prepared for the complex challenges of contemporary technical workplaces.

Acknowledgments

I am grateful to the faculty members and students of the Faculty of Engineering at the University of Surabaya for granting permission to collect data for this research.

References

Abbu, H., Mugge, P., Gudergan, G., Hoeborn, G., & Kwiatkowski, A. (2022). Measuring the Human Dimensions of Digital Leadership for Successful Digital Transformation. *Research-Technology Management, 65*(3), 39-49. https://doi.org/10.1080/08956308.2022.2048588

Adel, A. (2024). The Convergence of Intelligent Tutoring, Robotics, and IoT in Smart Education for the Transition from Industry 4.0 to 5.0. *Smart Cities, 7*(1), 325-369. https://doi.org/10.3390/smartcities7010014

Al-Maskari, A., Al Riyami, T., & Ghnimi, S. (2022). Factors affecting students' preparedness for the fourth industrial revolution in higher education institutions. *Journal of Applied Research in Higher Education, 16*(1), 246-264. https://doi.org/10.1108/jarhe-05-2022-0169

Al Hinai, M. R., Bhuiyan, A. B., & Husin, N. A. (2021). The Effects of Human Capital Attributes on the Employability Readiness Among Engineering Graduates in the High Education Institute's in Oman. *American International Journal of Business and Management Studies, 3*(1), 34-48. https://doi.org/10.46545/aijbms.v3i1.222

Cimatti, B. (2016). Definition, Development, Assessment of Soft Skills and Their Role for the Quality of Organizations and Enterprises. *International Journal for Quality Research, 10*(1), 97-130. https://doi.

org/10.18421/IJQR10.01-05

Darmawan, I. G. N., Suryadi, A., Budimansyah, D., & Susilo, S. (2024). *Indonesian Education: Past, Present, and Future*. Routledge. https://doi.org/10.4324/9781032657400

Fang, H.-L. (2025). Enhancing Student Learning Confidence and Career Readiness through Instructor Demonstration and Industry Collaboration: An Empirical Study of Hairdressing Education in Taiwan. *Research Square*. https://doi.org/10.21203/rs.3.rs-6318289/v1

Heydemans, C. D., Hadi, S., Suswanto, H., Firdaus, S. M., & Kaumbur, G. E. (2025). Innovation in Industry-based Learning in Vocational Education: A Systematic Review of Best Practices in Various Countries and Their Relevance to Indonesia. *Educatione, 3*(2), 472-482. https://doi.org/10.59397/edu.v3i2.58

Hora, M. T., Benbow, R. J., & Smolarek, B. B. (2018). Re-thinking Soft Skills and Student Employability: A New Paradigm for Undergraduate Education. *Change: The Magazine of Higher Learning, 50*(6), 30-37. https://doi.org/10.1080/00091383.2018.1540819

Imbar, V. R., Supangkat, H. S., Langi, A., & Arman, A. A. (2022). Digital transformation readiness in Indonesian institutions of higher education. *World Transactions on Engineering and Technology Education, 20*(2), 101-106. https://www.wiete.com.au/journals/WTE&TE/Pages/Vol.20,%20No.2%20(2022)/04-Imbar-R.pdf

Jackson, D. (2019). Student Perceptions of the Development of Work Readiness in Australian Undergraduate Programs. *Journal of College Student Development, 60*(2), 219-239. https://doi.org/10.1353/csd.2019.0020

Jadhav, P. (2025). Bringing Placement Drives to Tier-2 and Tier-3 Colleges in India: An AI-Supported Strategic Approach. *academia.edu*. https://www.academia.edu/143179882

Kholifah, N., Nurtanto, M., Mutohhari, F., Subakti, H., Ramadhan, M. A., & Majid, N. W. A. (2024). The mediating role of motivation and professional development in determining teacher performance in vocational schools. *Cogent Education, 11*(1), 2421094. https://doi.org/10.1080/2331186X.2024.2421094

Kholifah, N., Nurtanto, M., Sutrisno, V. L. P., Majid, N. W. A., Subakti, H., Daryono, R. W., et al. (2025). Unlocking workforce readiness through digital employability skills in vocational education Graduates: A PLS-SEM analysis based on human capital Theory. *Social Sciences & Humanities Open, 11*, 101625. https://doi.org/10.1016/j.ssaho.2025.101625

Lamri, J., & Lubart, T. (2023). Reconciling Hard Skills and Soft Skills in a Common Framework: The Generic Skills Component Approach. *Journal of Intelligence, 11*(6), 107. https://doi.org/10.3390/jintelligence11060107

Lane, C. (2023). *A Descriptive Study of Louisiana 4-H 8th Through 12th Graders' Perceptions of Career and College Readiness* [Master's thesis, Louisiana State University and Agricultural & Mechanical College]. https://repository.lsu.edu/gradschool_theses/5882

Lohmann, J. R., Rollins, H. A., & Joseph Hoey, J. (2006). Defining, Developing and Assessing Global Competence in Engineers. *European Journal of Engineering Education, 31*(1), 119-131. https://doi.org/10.1080/03043790500429906

Luo, J., Chan, C. K. Y., & Zhao, Y. (2023). The development and validation of an instrument to measure evaluative judgement: a focus on engineering students' judgement of intercultural competence. *Assessment & Evaluation in Higher Education, 48*(8), 1178-1194. https://doi.org/10.1080/02602938.2023.2222937

Martínez Gómez, J., & Nicolalde, J. F. (2025). Development of soft and hard skills with a better employability vision for engineering students. *Frontiers in Education, 10*, 1578287. https://doi.org/10.3389/feduc.2025.1578287

Mavrin, A. S. (2022). Features of the Development of Soft and Hard Skills in People of Generation Z. *SMALTA International Scientific-Practical and Methodical Journal,* (3), 5-16. https://doi.org/10.15293/2312-1580.2203.01

Mitchell, A., & Vaughan, A. G. (2022). Implementing Team-Based Learning: Findings From a Database Class. *Journal of Information Technology Education. Innovations in Practice, 21*, 1-23. https://doi.org/10.28945/4903

Mpanza, C. K. (2025). Challenges faced by Teachers in Conducting Classroom assessments in Secondary

Schools: A Case of Kabwe District. *International Journal for Multidisciplinary Research (IJFMR), 7*(4), 1-23. https://doi.org/10.36948/ijfmr.2025.v07i04.53221

Musa, S., Nurhayati, S., & Boriboon, G. (2025). The Effect of Internships on Graduates' Employability, Soft Skills, and Digital Competence. *Educational Process: International Journal, 17*, e2025306. https://doi.org/10.22521/edupij.2025.17.306

National Association of Colleges and Employers. (2022). *Career Readiness: Development and Validation of the NACE Career Readiness Competencies*. NACE Center for Career Development and Talent Acquisition. https://www.naceweb.org/uploadedFiles/files/2022/resources/2022-nace-career-readiness-development-and-validation.pdf

Nurizinova, M., Rizakhojayeva, G., Ramankulov, S., Akeshova, M., Tuyakov, Y., & Abdrakhmanov, R. (2025). STEM-based approaches to soft skills development: a synthesis of meta-analytic findings and empirical evidence. *Frontiers in Education, 10*, 1663155. https://doi.org/10.3389/feduc.2025.1663155

Orih, D., Heyeres, M., Morgan, R., Udah, H., & Tsey, K. (2024). A systematic review of soft skills interventions within curricula from school to university level. *Frontiers in Education, 9*, 1383297. https://doi.org/10.3389/feduc.2024.1383297

Peersia, K., Rappa, N. A., & Perry, L. B. (2024). Work readiness: definitions and conceptualisations. *Higher Education Research & Development, 43*(8), 1830-1845. https://doi.org/10.1080/07294360.2024.2366322

Sanz-Angulo, P., Galindo-Melero, J., De-Diego-Poncela, S., & Martín, Ó. (2025). Promoting soft skills in higher engineering education: Assessment of the impact of a teaching methodology based on flipped learning, cooperative work and gamification. *Education and Information Technologies, 30*(10), 13463-13506. https://doi.org/10.1007/s10639-025-13322-0

Scholapurapu, P. K. (2025). Artificial Intelligence-Powered Learning Analytics and Student Feedback Mechanisms for Dynamic Curriculum Enhancement and Continuous Quality Improvement in Outcome-Based Education. *SSRN*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5382140

Sholiha, E. U. N., & Salamah, M. (2015). Structural Equation Modeling-Partial Least Square untuk Pemodelan Derajat Kesehatan Kabupaten/Kota di Jawa Timur (Studi Kasus Data Indeks Pembangunan Kesehatan Masyarakat Jawa Timur 2013). *Jurnal Sains Dan Seni ITS, 4*(2), 169-174. https://doi.org/10.12962/j23373520.v4i2.10443

Shore, A., & Dinning, T. (2023). Developing student's skills and work readiness: an experiential learning framework. *Journal of Work-Applied Management, 15*(2), 188-199. https://doi.org/10.1108/jwam-02-2023-0016

Symonenko, S. (2020). Complementing content of English courses for enhancing communication of IT-professionals for sustainable development. *E3S Web of Conferences, 166*, 10008. https://doi.org/10.1051/e3sconf/202016610008

Zinecker, T. (2024). *The Effect of STEAM on the ACT STEM Benchmark* [Doctoral dissertation, Southwest Baptist University]. https://www.proquest.com/openview/dfd5a4e19bcff66fd2a1956f72a8c545