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Multidimensional Employability Skills for Electronics Engineering Graduates: A Systematic Review

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Abstract

Graduate employability in engineering increasingly requires competencies that extend beyond technical knowledge as professional roles evolve with changing industry demands. However, evidence regarding the employability skills required for electronics engineering graduates remains dispersed across educational and professional contexts. This systematic review synthesised the employability skills required for electronics engineering graduates, examined their broader competency dimensions, and identified research gaps and future directions. Following PRISMA 2020, studies were identified through Scopus and Web of Science and screened using predefined eligibility criteria. A total of 21 studies published between 2021 and 2026 were analysed through coding and thematic synthesis. Thirteen recurring employability skills were identified, with problem-solving (33.3%), technical competence (23.8%), and collaboration (19.0%) reported most frequently. The skills were organised into six categories: interpersonal, cognitive, personal attributes, technical, professionalism, and career-related skills. Four research-gap themes were identified, led by limited empirical validation and generalisability (42.9%) and curriculum-industry alignment and experiential learning gaps (33.3%). Overall, electronics engineering employability is multidimensional, requiring integrated technical and non-technical competencies and stronger education-industry alignment to prepare graduates for professional practice and continued career development.

Keywords: Electronics Engineering, Employability Skills, Graduate Employability, Multidimensional Competencies, Systematic Review

Introduction

The engineering and electronics labour market is undergoing significant transformation driven by rapid technological advancement and industrial digitalisation, particularly in artificial intelligence (AI), the Internet of Things (IoT), automation and other emerging technologies (Tomun et al., 2025; Wei et al., 2026). These developments are reshaping

workforce competency requirements, with increasing emphasis on digital and technology-related capabilities needed to respond to evolving engineering roles and industrial practices (Tomun et al., 2025; Wei et al., 2026). The changing nature of engineering work has consequently increased demand for engineers with an appropriate combination of skills, creating challenges for industries in securing a workforce that meets evolving occupational requirements (Tzagkas et al., 2026). This shift is also reflected in employer expectations, where digital skills have become increasingly prominent alongside the broader technical and generic competencies required of engineering professionals (Kaushal & Vaghela, 2023).

Within this changing employment landscape, employability skills have become an important consideration for higher education institutions, employers and other stakeholders because of their role in supporting graduates' transition into the workplace and longer-term occupational development (Li et al., 2022; Maina et al., 2022). Rather than representing a single set of abilities, employability is increasingly viewed as a multidimensional construct that encompasses different forms of knowledge, competencies, personal capabilities and career-related attributes (Tong & Gao, 2022; Li et al., 2022). Empirical studies across different disciplinary contexts further demonstrate this multidimensionality, with employability incorporating professional knowledge, generic competencies, career management, self-efficacy, adaptability, critical thinking, professional ethics, innovation and teamwork (Tong & Gao, 2022; Peng & Deng, 2022). This broader understanding suggests that preparing graduates for employment requires the development of complementary competencies that extend beyond disciplinary knowledge alone (Maina et al., 2022; Peng & Deng, 2022).

The specific context of electronics engineering graduates is characterised by continuous technological development, changing professional roles and evolving industry skill requirements. Developments in the electronics industry have continually reshaped career roles and graduate competency requirements, creating a need for engineering education to remain responsive to professional and industrial practices (Fan et al., 2023). At the same time, skills mismatch remains a persistent concern in the electrical and electronics industry, with gaps reported in both soft and hard skills associated with current industry requirements (Rodzalan et al., 2022). Electrical and electronic engineering programmes therefore need to address a broad range of graduate attributes, including technical competence, ethics, professionalism, and leadership, while giving greater attention to entrepreneurship, multidisciplinary capabilities and soft skills (Ab-Rahman et al., 2022). This need is further reinforced by Industry 4.0 developments, where emerging technologies such as IoT require electronics education and technological training to be continuously updated in response to changing professional knowledge and industry demands (Mendes et al., 2024).

Despite growing attention to graduate employability in engineering education, the existing literature remains fragmented in how employability competencies are conceptualised, developed and assessed. The conceptualisation and measurement of engineering employability remain contested, with recent reviews highlighting the need for greater conceptual clarity, discipline specificity, holistic developmental approaches and stronger empirical validation (Zhan et al., 2025). Similar inconsistencies are evident in skills development, where there is still limited agreement regarding which soft and transversal skills should be prioritised, how they should be taught and how their development should be assessed across engineering education contexts (Friesel et al., 2022). Moreover, evidence

linking pedagogical approaches to generic competence development has often been theoretically argued or derived from individual teaching cases, indicating limitations in the consolidation of evidence concerning how such competencies are effectively developed (Boelt et al., 2022). These concerns are reinforced by broader reviews of engineering professional skills, which report a lack of clear consensus regarding which competencies are being developed and the most effective approaches for developing them (Chadha & Heng, 2024).

Given the fragmented understanding of employability competencies and the continuing need to align engineering education with evolving industry requirements, a systematic synthesis focused on electronics engineering graduates is warranted. Existing studies have reported discrepancies between competencies expected in professional practice and those emphasised within engineering education, while discipline-specific studies have further highlighted the need for curricula to respond to industry-oriented knowledge and skill requirements (Al Mestiraihi & Becker, 2023; Masoud & Issa, 2023). Accordingly, this systematic review aims to identify and synthesise the employability skills required for electronics engineering graduates, examine the broader themes through which these skills are represented in the literature and identify research gaps and future directions.

The review is guided by the following research questions:
RQ1. What employability skills are required for electronics engineering graduates?
RQ2. What are the key themes of employability skills identified in the existing literature on electronics engineering graduates?
RQ3. What research gaps and future directions have been identified regarding employability skills for electronics engineering graduates?

This review contributes to the existing knowledge by providing a structured synthesis of employability competencies relevant to electronics engineering graduates, together with the broader competency dimensions, research gaps and future directions identified across the literature. By consolidating these perspectives, the review provides an evidence base for strengthening alignment between engineering education and evolving industry requirements. From a practical perspective, the findings may support educators and curriculum developers in designing learning experiences that develop multidimensional employability competencies and better prepare electronics engineering graduates for professional practice and continued career development.

Methodology

This systematic review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to support a transparent and systematic process of study identification, screening and inclusion (Page et al., 2021). Relevant peer-reviewed literature was identified through Scopus and Web of Science (WoS), which served as the primary bibliographic databases for the review. The review process involved systematic searching, application of predefined eligibility criteria, screening of retrieved records, assessment of eligible studies, data extraction and synthesis of the included literature. These procedures were undertaken to identify and synthesise evidence concerning employability skills required for electronics engineering graduates.

The review was designed as a systematic synthesis of recent literature concerning employability skills relevant to electronics engineering graduates. The review process comprised the identification and screening of relevant studies, assessment against predefined eligibility criteria, and inclusion of studies that met the scope of the review. Following study selection, relevant information was systematically extracted and analysed in accordance with the three research questions. The analysis focused on identifying employability skills reported in the literature, organising these skills into broader competency themes, and synthesising the research gaps and future directions reported across the included studies.

A systematic search was conducted in Scopus and Web of Science (WoS) to identify relevant studies on employability skills for electronics engineering graduates. Table 1 presents the search strategy, which combined three main concepts: employability-related terms, engineering-related terms and electronics-related terms using Boolean operators. The initial database search retrieved 486 records, comprising 337 records from Scopus and 149 records from WoS. The Scopus results were subsequently limited to publications from 2021 to 2026, journal source type, article document type and the English language, resulting in 37 records. Similarly, the WoS results were limited to publications from 2021 to 2026, article document type and the English language, resulting in 22 records.

Table 1
Search strategy used for study identification

	Search concept	**Search terms**
1.	*Employability*	employability OR “graduate employability” OR “employability skill*” OR “graduate competenc*” OR “graduate attribute*” OR “professional competenc*” OR “work readiness” OR “career readiness” OR “technical skill*” OR “professional skill*” OR “soft skill*” OR “future skill*”
2.	*Engineering*	engineering OR engineer*
3.	*Electronics*	electronics OR “electronic engineering” OR semiconductor* OR microelectronics OR “electronics industr*” OR “electronics manufacturing”
4.	*Combined search*	(Employability terms) AND (Engineering terms) AND (Electronics terms)

Studies were included if they were journal articles published in English between 2021 and 2026 and examined employability skills, competencies, graduate attributes, work readiness, or related professional capabilities relevant to electronics engineering graduates or closely related engineering contexts. Studies were excluded if they were outside the specified publication period, were not journal articles, were published in languages other than English or did not provide evidence relevant to the scope and research questions of the review.

Following database filtering, 59 records were retained for the study selection process. A total of 21 duplicate records were identified and removed, leaving 38 records for title and abstract screening. Based on the predefined eligibility criteria, 16 records were excluded because they did not meet the scope of the review, resulting in 22 articles for full-text assessment. During the full-text assessment, one article was excluded because its content was not relevant to the

focus of the review. Consequently, 21 studies met the eligibility criteria and were included in the final systematic review. The study selection process is summarised in the PRISMA flow diagram in Figure 1.

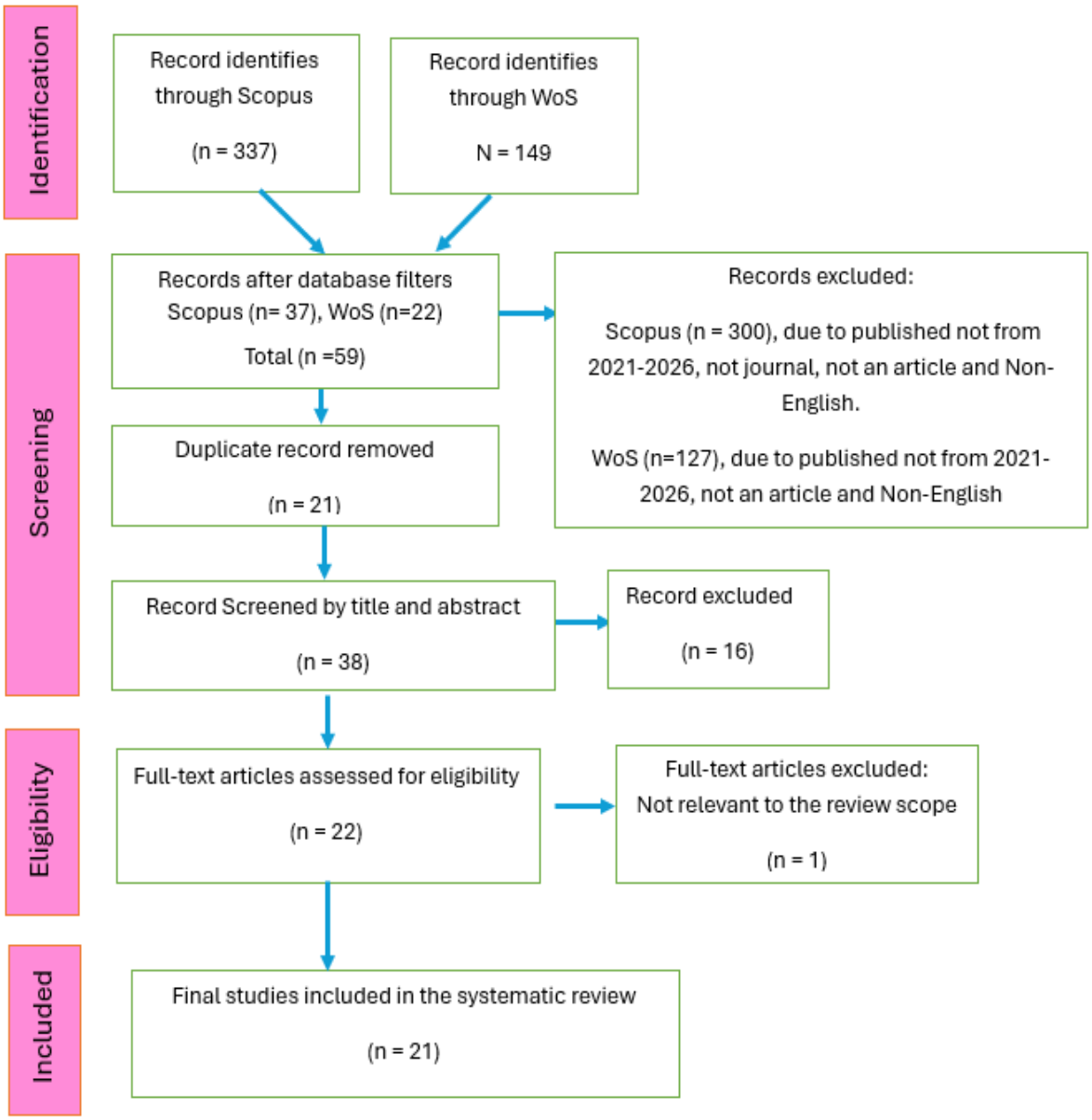


Figure 1. PRISMA Flow Diagram of The Study Selection Process.

The quality of the included studies was assessed using six quality assessment criteria adapted from Abouzahra et al. (2020), following the general principles of systematic literature review proposed by Kitchenham (2007). Each criterion was rated as "Yes" (Y), "Partly" (P), or "No" (N), corresponding to scores of 1, 0.5 and 0, respectively.

The criteria assessed in this study are defined as follows:
QA1. Is the purpose of the study clearly stated?
QA2. Are the relevance and usefulness of the work clearly presented?
QA3. Is the study methodology clearly established?
QA4. Are the concepts underlying the approach clearly defined?

QA5. Is the work compared and evaluated in relation to similar studies?
QA6. Are the limitations of the study clearly reported?

The scores were summed to obtain a maximum quality score of 6 for each study and subsequently converted into percentages. The quality assessment was used to evaluate the quality and reporting clarity of the included evidence rather than as an additional criterion for study exclusion. The results of the quality assessment are presented in Table 2.

Table 2
Quality Assessment Results.

Study ID	*QA1*	*QA2*	*QA3*	*QA4*	*QA5*	*QA6*	Total	%
S1	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S2	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S3	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S4	1.0	1.0	0.5	1.0	1.0	0.5	5.0	83.33
S5	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S6	1.0	0.5	0.5	0.5	0.5	1.0	4.0	66.67
S7	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S8	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S9	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S10	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S11	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S12	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S13	1.0	1.0	0.5	1.0	0.5	0.0	4.0	66.67
S14	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S15	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S16	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S17	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S18	1.0	1.0	1.0	1.0	1.0	1.0	6.0	100.00
S19	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S20	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67
S21	1.0	1.0	1.0	1.0	1.0	0.5	5.5	91.67

Data from the included studies were systematically extracted using a structured data extraction matrix. The extracted information included author and year of publication, country, study aim, research method, participants, main findings, supporting evidence, employability skill codes, skill categories, emerging themes, and corresponding research questions. The main findings and supporting evidence from each study were examined to identify employability skills relevant to electronics engineering graduates. The identified skills were then coded and grouped into broader categories based on similarities in their meanings and contexts. Emerging themes were subsequently developed from the categorized evidence and mapped to the relevant research questions to support the synthesis of findings.

The extracted data were analyzed using descriptive frequency analysis and thematic synthesis in accordance with the three research questions. For RQ1, the identified employability skill codes were reviewed and harmonized to consolidate terms with similar meanings while

preserving their original contexts. The frequency of each skill was then determined based on the number of studies reporting the skill, with each skill counted only once per study regardless of repeated mentions within the same article. For RQ2, the identified skills were compared based on conceptual similarities and grouped into broader employability skill categories. The frequency and percentage of each category were subsequently calculated based on the coded skill occurrences across the included studies. For RQ3, information relating to study limitations, research gaps, recommendations and future research directions was examined and synthesized thematically. Similar issues were grouped and refined into broader research-gap themes representing recurring limitations and future research needs across the literature.

Results

Characteristics of the Included Studies

The 21 studies included in this systematic review were published between 2021 and 2026 and represented diverse geographical contexts. The distribution of studies by publication year is presented in Figure 2. The highest number of studies was published in 2021, with five studies (23.8%). This was followed by four studies (19.0%) each in 2023, 2024, and 2025, while two studies (9.5%) each were published in 2022 and 2026. The studies represented 14 identified countries, with India contributing the most (n = 3), followed by China, Malaysia, Spain and the United Kingdom (n = 2 each). The remaining countries contributed one study each, while one conceptual study had no specific geographical context. This geographical and temporal distribution provides a broad context for understanding the methodological characteristics of the included studies.

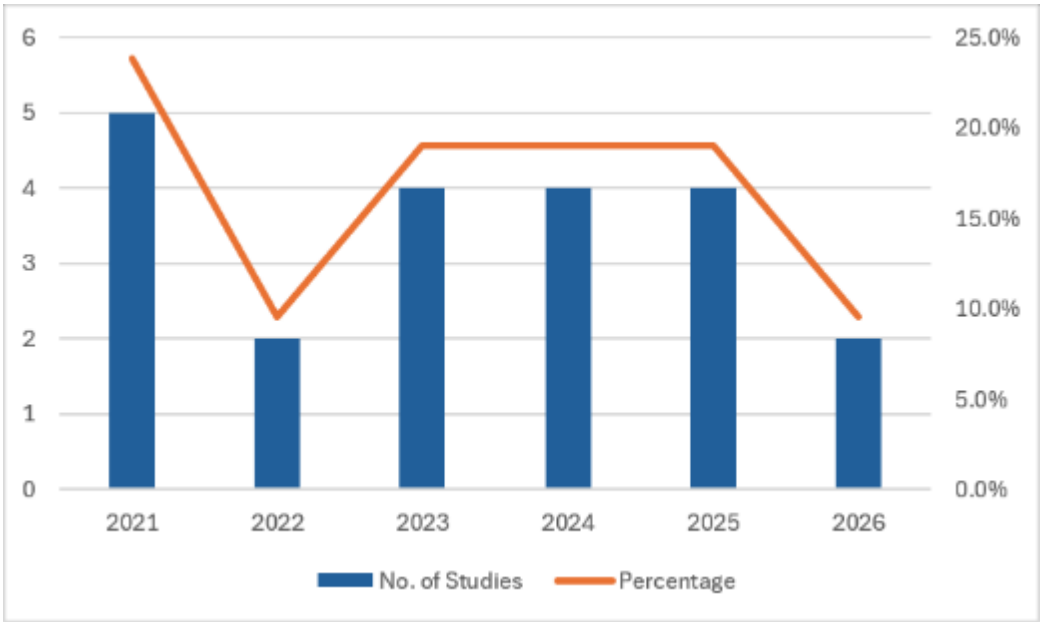


Figure 2. Distribution of Included Studies by Publication Year.

Quantitative approaches were the most common (n = 7, 33.3%), followed by qualitative and mixed methods approaches (n = 5, 23.8% each). Descriptive approaches accounted for two studies (9.5%), while quasi-experimental and conceptual approaches each accounted for one study (4.8%). Figure 3 presents the distribution of employability skill categories identified across the included studies. The Participants and data sources included electrical and

electronic engineering students, engineering graduates, lecturers and experts, curriculum documents, labour-market data and résumé datasets. Together, these diverse methodological approaches and evidence sources provide the foundation for examining the employability skills identified across the included studies.

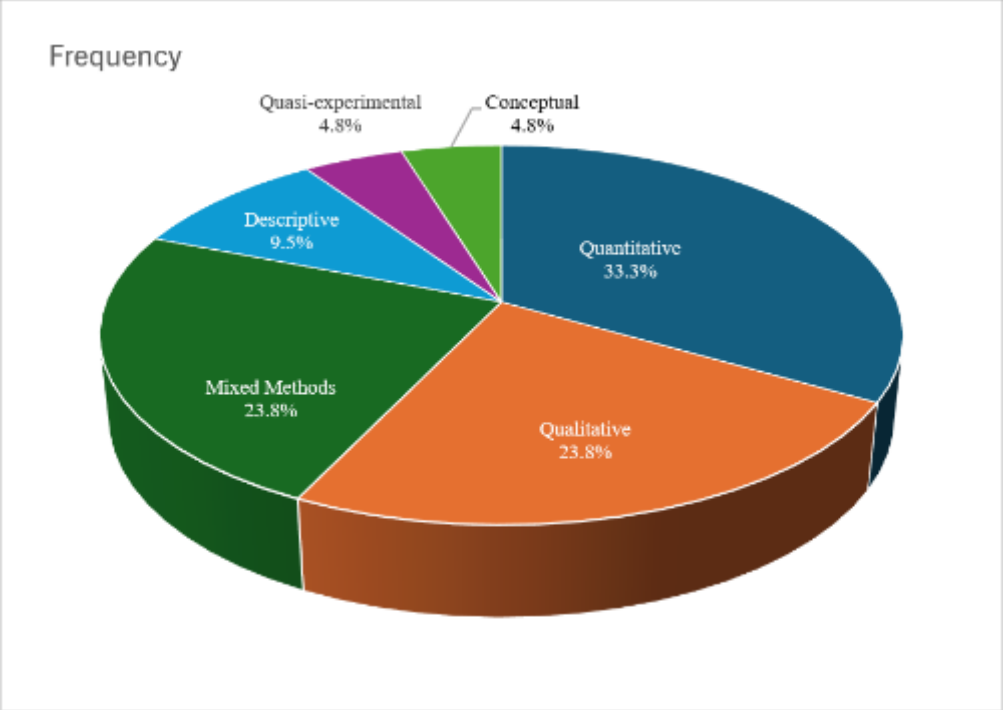


Figure 3. Distribution of Included Studies by Research Approach.

Employability Skills Required for Electronics Engineering Graduates

The analysis identified 13 recurring employability skills across the 21 included studies, as presented in Table 3. Problem-solving was the most frequently reported skill, appearing in seven studies (33.3%), followed by technical competence in five studies (23.8%) and collaboration in four studies (19.0%). Practical skills, innovation and soft skills were each identified in three studies (14.3%). Teamwork, professional competence, creativity, communication, critical thinking, management and leadership were each reported in two studies (9.5%). The variation in the frequency of these skills also reflects the diverse competency dimensions associated with graduate employability.

The identified skills represented a combination of technical and non-technical competencies. Problem-solving, critical thinking, and innovation were associated with cognitive skills, while technical competence and practical skills represented the technical dimension. Collaboration, teamwork, communication, management, and leadership reflected interpersonal skills, whereas creativity and soft skills were associated with personal attributes. Professional competence represented a career-related dimension. Overall, the identified employability skills comprised both technical and non-technical competencies across several skill dimensions, providing the basis for examining how these skills can be organised into broader employability skill categories.

Table 3
Identification of employability skills across the 21 included studies.

	Employability Skills	Frequency	Percentage	Corresponding Studies
1.	Problem-solving	7	33.3%	(Fan et al., 2023), (Hussain et al., 2026), (Hayashi et al., 2023), (Alvarado-Bravo et al., 2022), (Wu et al., 2025), (Velasco et al., 2021), (Madhavi et al., 2024)
2.	Technical Competence	5	23.8%	(Hong et al., 2024), (Fan et al., 2023), (Zhang et al., 2025), (Itagi et al., 2021), (Ab-Rahman et al., 2022)
3.	Collaboration	4	19.0%	(Fan et al., 2023), (Hussain et al., 2026), (Hayashi et al., 2023), (Madhavi et al., 2024)
4.	Practical Skills	3	14.3%	(Hussain et al., 2026), (Alvarado-Bravo et al., 2022), (Itagi et al., 2021)
5.	Innovation	3	14.3%	(Llorens et al., 2025), (Wu et al., 2025), (Nikoloudakis & Rangoussi, 2024)
6.	Soft Skills	3	14.3%	(Zhang et al., 2025), (Álvarez Salazar et al., 2023), (Ab-Rahman et al., 2022)
7.	Teamwork	2	9.5%	(Fan et al., 2023), (Itagi et al., 2021)
8.	Professional Competence	2	9.5%	(Madhavan et al., 2026), (Myllien et al., 2025)
9.	Creativity	2	9.5%	(Llorens et al., 2025), (Nikoloudakis & Rangoussi, 2024)
10.	Communication	2	9.5%	(Hayashi et al., 2023), (Velasco et al., 2021)
11.	Critical Thinking	2	9.5%	(Hayashi et al., 2023), (Madhavi et al., 2024)
12.	Management	2	9.5%	(Wu et al., 2025), (Velasco et al., 2021)
13.	Leadership	2	9.5%	(Daley & Baruah, 2021), (Ab-Rahman et al., 2022)

Major Categories/Key Themes of Employability Skills

The employability skills identified across the included studies were organised into six major categories, as presented in Table 4. Interpersonal skills represented the largest proportion, accounting for 19 of the 76 coded occurrences (25.0%). Cognitive Skills and Personal Attributes followed with 16 occurrences each (21.1%), while Technical Skills accounted for 10 occurrences (13.2%). Professionalism represented eight occurrences (10.5%), whereas Career-related skills accounted for seven occurrences (9.2%). The distribution demonstrates that the identified employability skills were distributed across multiple competency categories rather than concentrated within a single dimension.

Table 4
Identification of six major categories/key themes of employability skills

	Major Category/Key Themes	Frequency	Percentage	Corresponding Studies
1.	*Interpersonal Skills*	19	25.0%	(Fan et al., 2023), (Hussain et al., 2026), (Hayashi et al., 2023), (Wu et al., 2025), (Zhang et al., 2025), (Itagi et al., 2021), (Velasco et al., 2021), (Daley & Baruah, 2021), (Madhavi et al., 2024), (Ab-Rahman et al., 2022), (Arabacı Atlamaz et al., 2024)
2.	*Cognitive Skills*	16	21.1%	(Hong et al., 2024), (Fan et al., 2023), (Hussain et al., 2026), (Madhavan et al., 2026), (Llorens et al., 2025), (Hayashi et al., 2023), (Alvarado-Bravo et al., 2022), (Wu et al., 2025), (Nikoloudakis & Rangoussi, 2024), (Velasco et al., 2021), (Madhavi et al., 2024)
3.	*Personal Attributes*	16	21.1%	(Sharma et al., 2023), (Ooi, 2021), (Myllien et al., 2025), (Llorens et al., 2025), (Nikoloudakis & Rangoussi, 2024), (Álvarez Salazar et al., 2023), (Hidayat et al., 2021), (Arabacı Atlamaz et al., 2024)
4.	*Technical Skills*	10	13.2%	(Hong et al., 2024), (Fan et al., 2023), (Hussain et al., 2026), (Alvarado-Bravo et al., 2022), (Wu et al., 2025), (Zhang et al., 2025), (Itagi et al., 2021), (Ab-Rahman et al., 2022)
5.	*Professionalism*	8	10.5%	(Madhavan et al., 2026), (Álvarez Salazar et al., 2023), (Madhavi et al., 2024), (Ab-Rahman et al., 2022)
6.	*Career-related Skills*	7	9.2%	(Madhavan et al., 2026), (Ooi, 2021), (Myllien et al., 2025), (Alvarado-Bravo et al., 2022), (Hidayat et al., 2021), (Ab-Rahman et al., 2022)
	Total	76	100.0%	

The six categories captured different dimensions of employability reported across the reviewed studies. Interpersonal Skills encompassed competencies related to interaction and working with others, while Cognitive Skills reflected thinking and problem-solving capabilities. Personal Attributes represented individual qualities and behaviours, whereas Technical Skills covered competencies associated with technical and practical capabilities. Professionalism reflected competencies related to professional conduct and responsibilities, while career-related skills represented competencies associated with career and workplace development. Together, these categories provide a structured representation of the employability skills identified in the literature and establish a basis for examining the research gaps and future directions associated with their development and evaluation.

Research Gaps and Future Directions

The analysis identified four major research gap themes across the 21 included studies as presented in Table 5. Limited Empirical Validation and Generalisability was the most frequently identified gap, reported in nine studies (42.9%). This was followed by Curriculum–Industry Alignment and Experiential Learning Gaps in seven studies (33.3%). Limited Scope and Coverage of Employability Skills Research was identified in three studies (14.3%), while Pedagogical Implementation and Skill Development Challenges were reported in two studies (9.5%). The concentration of studies within the first two themes highlights the recurring attention given to empirical validation and curriculum–industry alignment within the reviewed literature.

Table 5
Identification of four major research gap themes across the 21 included studies

	Research Gap Themes	Frequency	Percentage	Corresponding Studies
1.	*Limited Empirical Validation and Generalisability*	9	42.9%	(Hong et al., 2024), (Fan et al., 2023), (Hussain et al., 2026), (Ooi, 2021), (Myllien et al., 2025), (Hayashi et al., 2023), (Nikoloudakis & Rangoussi, 2024), (Velasco et al., 2021), (Arabacı Atlamaz et al., 2024)
2.	*Curriculum–Industry Alignment and Experiential Learning Gaps*	7	33.3%	(Madhavan et al., 2026), (Sharma et al., 2023), (Wu et al., 2025), (Itagi et al., 2021), (Álvarez Salazar et al., 2023), (Daley & Baruah, 2021), (Ab-Rahman et al., 2022)
3.	*Limited Scope and Coverage of Employability Skills Research*	3	14.3%	(Llorens et al., 2025), (Zhang et al., 2025), (Hidayat et al., 2021)
4.	*Pedagogical Implementation and Skill Development Challenges*	2	9.5%	(Alvarado-Bravo et al., 2022), (Madhavi et al., 2024)
	Total	21	100.0%	

The identified gaps also pointed to several directions for future research. Studies within the empirical validation and generalisability theme emphasised the need for larger and more diverse samples, objective assessment methods, longitudinal designs, and validation across different educational and disciplinary contexts. Studies addressing curriculum–industry alignment highlighted the need for stronger integration of industry-relevant competencies, practical and experiential learning, and closer engagement between educational institutions and industry. Other studies called for broader coverage of employability skills and contributing factors, while pedagogical studies highlighted the need to strengthen the implementation and evaluation of approaches used to develop practical and professional competencies. Collectively, these research gaps and proposed directions provide a basis for further discussion of how existing evidence can inform the development of employability skills among electronics engineering graduates.

Discussion

Employability Skills Required for Electronics Engineering Graduates

Problem-solving emerged as the most frequently reported employability skill, indicating its prominence across both educational and employment-related contexts. Several studies associated its development with project-based and experiential learning. Interdisciplinary PBL facilitated complex problem-solving for engineering practice (Fan et al., 2023), while project-based engineering experiences strengthened problem-solving alongside design thinking and interdisciplinary collaboration (Hussain et al., 2026). Similar outcomes were reported in remote project-based learning (Hayashi et al., 2023) and value-based PBL activities involving real-world engineering challenges (Madhavi et al., 2024). Beyond educational settings, problem-solving was associated with skills valued in higher-paying engineering positions (Wu et al., 2025) and contributed to practicum success and professional readiness (Velasco et al., 2021). However, Alvarado-Bravo et al. (2022) reported that students' case-solving and practical professional skills still required further improvement in online learning, suggesting that exposure to learning activities does not necessarily ensure adequate skill development. Taken together, these findings position problem-solving as both an educational outcome and an employment-relevant competency, while highlighting the importance of learning environments that provide meaningful opportunities for its practical application.

Technical competence, the second most frequently identified skill, further demonstrates the importance of discipline-specific capability in preparing graduates for engineering practice. Different pedagogical approaches showed comparable contributions to its development, with CDIO-based learning strengthening technical competence and job-specific skills (Hong et al., 2024), while interdisciplinary PBL supported technical competence alongside other professional capabilities required for engineering practice (Fan et al., 2023). This development was extended into practical application through industry-oriented product design activities, where students applied technical concepts and developed hands-on skills aligned with industry needs (Itagi et al., 2021). The relevance of technical competence beyond educational settings was further supported by Zhang et al. (2025), who found that electronic engineering careers were strongly characterised by discipline-specific technical skills. However, technical competence was not represented as an isolated employability requirement. Ab-Rahman et al. (2022) identified technical competence alongside ethics, professionalism, leadership, multidisciplinary capabilities and soft skills, while Zhang et al. (2025) also highlighted the role of soft skills in cross-disciplinary career transitions. Collectively, these findings suggest that technical competence provides an important foundation for engineering employability, but its contribution is strengthened when combined with practical application and broader non-technical competencies required in professional environments.

Collaboration further illustrates the importance of non-technical competencies alongside technical capability in engineering employability. Across different project-based learning environments, students consistently developed collaborative capabilities through active engagement with engineering tasks. Interdisciplinary PBL promoted teamwork and collaboration in addressing complex engineering problems (Fan et al., 2023), while project-based engineering experiences facilitated interdisciplinary collaboration alongside practical and problem-solving skills (Hussain et al., 2026). This pattern extended beyond conventional

project settings, as fully remote PjBL also supported the development of collaboration and problem-solving (Hayashi et al., 2023). Similarly, value-based PBL fostered collaboration together with critical thinking and innovative problem-solving in addressing real-world challenges (Madhavi et al., 2024). However, Hayashi et al. (2023) found that improvements in collaboration were not accompanied by similar development in communication and critical thinking, indicating that professional skills may not develop uniformly within the same learning environment. Taken together, these findings suggest that collaboration benefits from learning environments that require active and shared engagement, while also demonstrating that broader employability development requires attention to multiple competencies rather than assuming that one pedagogical approach will develop all professional skills equally.

Beyond the three most frequently reported skills, the remaining competencies further demonstrate that engineering employability involves interconnected capabilities rather than isolated skills. Practical skills and professional competence extend technical knowledge into applied engineering practice, while innovation, critical thinking and creativity support graduates in analysing challenges and developing appropriate solutions. At the same time, soft skills, teamwork, communication, management, and leadership contribute to effective interaction and functioning within professional environments. Evidence across the reviewed studies further suggests that these capabilities are developed and demonstrated through varied contexts, including project-based, industry-oriented, community-based and practicum experiences, although their development is not necessarily uniform across different skills. Taken together, the findings suggest that employability in electronics engineering requires the integration of technical, cognitive, interpersonal and professional capabilities, providing a basis for examining the broader competency dimensions within which these skills are situated.

Multidimensional Nature of Employability Skills

The findings demonstrate that employability skills for electronics engineering graduates extend beyond technical capability and encompass multiple competency dimensions. Interpersonal skills represented the largest proportion of coded occurrences (25.0%), followed by cognitive skills (21.1%) and personal attributes (21.1%), collectively accounting for 67.2% of all coded occurrences. The prominence of these categories indicates substantial emphasis in the reviewed literature on graduates' non-technical capabilities. Interpersonal skills reflected the ability to communicate, collaborate, coordinate and work effectively with others, while cognitive skills supported problem-solving, decision-making, critical thinking and innovative thinking. Personal attributes further reflected graduates' capacity for self-management, adaptability, self-regulation and continued personal development. Together, these dimensions suggest that engineering employability involves not only what graduates know, but also how they think, interact with others and manage themselves within professional environments. This multidimensional emphasis, however, does not diminish the continuing importance of technical and professionally oriented competencies in preparing graduates for engineering careers.

Although less frequently represented in the coded occurrences, technical skills, professionalism, and career-related skills provide complementary dimensions of engineering employability. Technical skills reflected graduates' capacity to apply discipline-specific

competence through job-specific, practical and research and development capabilities. Professionalism extended this capability beyond task performance by incorporating ethical judgement, engineering ethics, civic and social responsibility, and commitment to professional conduct. Career-related skills further emphasised professional competence, work readiness, multidisciplinary capability, lifelong learning, and a growth mindset, reflecting the need for graduates to adapt and continue developing throughout their careers. These dimensions therefore complement the interpersonal, cognitive, and personal capabilities identified earlier by connecting graduates' ability to perform engineering work with responsible professional practice and continued career development.

Overall, the six categories demonstrate that employability in electronics engineering is multidimensional, involving competencies that enable graduates to think critically, interact effectively, manage themselves, perform technical tasks, act responsibly, and continue developing professionally. Rather than functioning independently, these dimensions collectively represent the broader capabilities required to support graduates' transition into and development within engineering careers. However, the extent to which these competencies have been empirically validated, effectively developed through engineering education, and aligned with industry requirements remains uneven across the literature, leading to several important research gaps and future directions.

Research Gaps and Future Directions

The most prominent research gap identified in the reviewed studies concerned limited empirical validation and generalisability, accounting for 42.9% of the identified research gaps. Several studies were constrained by small or narrowly defined samples, discipline-specific settings, or context-specific interventions, limiting the extent to which their findings could be generalised across engineering populations and educational environments. The strength of the available evidence was further constrained by reliance on self-reported perceptions, qualitative reflections, limited assessment approaches and the absence of experimental or control-group designs in some studies. In addition, repeated implementation and longitudinal evidence remain limited, leaving the longer-term effectiveness and retention of employability skill development insufficiently established. Future research should therefore employ larger and more diverse samples, stronger comparative or experimental designs, validated assessment approaches, and longitudinal evaluation to strengthen the empirical basis and generalisability of employability skills research.

A second major gap concerns curriculum–industry alignment and experiential learning, representing 33.3% of the identified research gaps. The reviewed studies indicate that engineering curricula do not consistently reflect the full range of competencies required by industry, with uneven integration of emerging employability skills and professional capabilities. At the same time, limited practical exposure, industry engagement, internships, and early experiential learning opportunities restrict students' ability to translate theoretical knowledge into practical application. These findings suggest that identifying relevant employability skills alone is insufficient unless such competencies are effectively integrated into curricula and supported by appropriate opportunities for application. Future engineering education should therefore strengthen continuous curriculum–industry alignment while expanding experiential, project-based, and industry-engaged learning opportunities to support the development of competencies relevant to evolving professional demands.

The remaining research gaps concerned the limited scope and coverage of employability research (14.3%) and challenges in pedagogical implementation and skill development (9.5%). Existing studies were often bounded by specific disciplinary, institutional, methodological, or variable-related contexts, restricting broader understanding of how employability skills and career-related outcomes may vary across settings. In addition, the adoption of pedagogical approaches does not necessarily ensure effective skill development, as some competencies remained insufficiently developed while implementation was constrained by challenges related to student engagement, teamwork, assessment, and learning resources. Future research should therefore broaden the contexts and competencies examined while continuously evaluating and refining pedagogical approaches to ensure that targeted employability skills are effectively developed across different educational and professional settings.

Overall, the identified gaps indicate that future employability research should move beyond identifying required skills towards establishing stronger empirical evidence, improving curriculum–industry alignment, expanding experiential learning opportunities, and evaluating how effectively these competencies are developed across diverse contexts. Addressing these gaps could strengthen the evidence base for designing engineering education that is responsive to evolving industry requirements and supports graduates' preparation for professional practice.

Implications of the Review

The findings of this review highlight the importance of closer collaboration between engineering education institutions and industry in ensuring that graduate competencies remain aligned with evolving professional requirements. Rather than focusing solely on the identification of employability skills, curriculum development should integrate the technical, cognitive, interpersonal, personal, professional, and career-related competencies required for engineering practice. This alignment should be supported by teaching and learning approaches that provide students with meaningful opportunities to develop and apply these competencies through project-based, experiential, and industry-engaged learning. Continuous industry involvement in curriculum review and learning activities could further support the relevance of graduate competencies to changing workplace expectations. Collectively, stronger curriculum–industry alignment and appropriate learning experiences may contribute to better preparation of electronics engineering graduates for professional practice and continued career development.

Limitations of the Review

This review has several limitations that should be considered when interpreting its findings. First, the literature search was limited to Scopus and Web of Science and to English-language journal publications within the specified review period; therefore, relevant evidence indexed in other databases or published through other sources may not have been captured. Second, although the review focused on employability skills relevant to electronics engineering graduates, some included studies were conducted within broader engineering or related disciplinary contexts, which may limit the direct applicability of certain findings to electronics engineering. Finally, the categorisation and thematic synthesis of employability skills and research gaps involved interpretive judgement, despite the use of a structured extraction and coding process. These limitations suggest that the findings should be interpreted within the

defined scope of the review while providing a basis for broader and more context-specific investigations in future research.

Conclusion

This systematic review synthesised the employability skills required for electronics engineering graduates and examined their broader competency dimensions, research gaps, and future directions. The findings identified 13 recurring employability skills, with problem-solving, technical competence, and collaboration emerging most prominently across the reviewed studies. These skills were organised into six interconnected categories comprising interpersonal skills, cognitive skills, personal attributes, technical skills, professionalism, and career-related skills, demonstrating that engineering employability extends beyond technical capability and involves multiple dimensions required for professional practice and career development. Despite this growing recognition, the literature remains constrained by limited empirical validation and generalisability, curriculum–industry alignment and experiential learning gaps, as well as narrower issues related to research scope and pedagogical implementation. Overall, the review highlights the need for closer collaboration between engineering education and industry to continuously align multidimensional employability competencies with evolving professional requirements and translate them into meaningful learning experiences that better prepare electronics engineering graduates for professional practice and continued career development.

Theoretically, this review contributes to the existing knowledge by consolidating fragmented employability skills reported in the literature into six interconnected competency dimensions: interpersonal skills, cognitive skills, personal attributes, technical skills, professionalism, and career-related skills. This multidimensional synthesis provides a more structured understanding of employability in engineering education, demonstrating that graduate employability extends beyond technical competence and involves the integration of multiple competencies required for professional practice and career development. Contextually, the review provides an electronics engineering-specific synthesis of employability requirements and highlights the need for closer alignment between graduate competencies, engineering education, and evolving industry expectations. These findings provide a relevant evidence base for curriculum review, industry–academia collaboration, and the development of electronics engineering graduates who are better prepared for changing workplace demands. Figure 4 provides an overview of the key findings, research gaps and future directions identified in this systematic review.

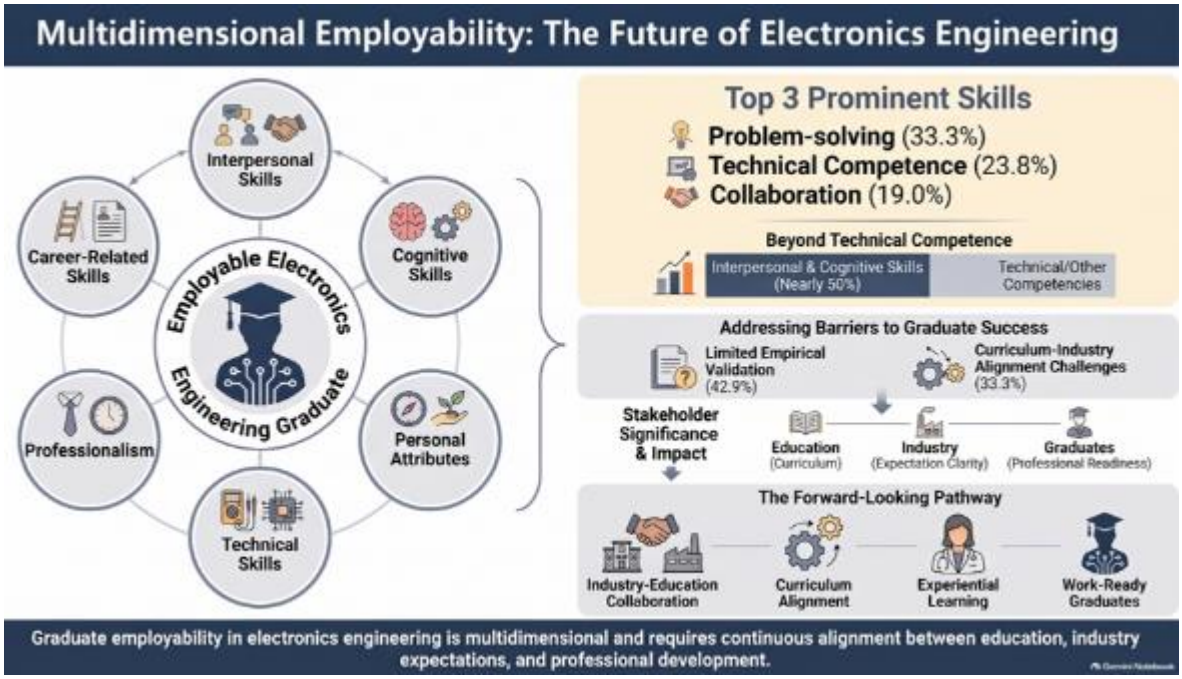


Figure 4. Overview of the Key Findings, Research Gaps and Future Directions of the Systematic Review

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