

Mapping ASEAN information and communication technology job trends to skills frameworks: A data-driven approach to aligning work-integrated learning

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This study investigates how real-time job analysis in Association of Southeast Asian Nations (ASEAN) can be used to design work-integrated learning (WIL) programs and enhance the alignment between information and communication technology (ICT) education and labor market needs. Using text analysis techniques, 4,443 ICT employment positions were mapped to the ASEAN ICT Skills Standard to identify regional labor demand patterns. The results reveal both country-specific and shared trends. Software development, cloud computing, and cybersecurity are consistently in demand, whereas the Internet of Things (IoT) and social business reflect national economic orientations. Based on these findings, five strategies are proposed to improve WIL design: (1) role- and cross-role focus, (2) alignment with emerging technological trends, (3) diversification across job families, (4) identification of emerging skill clusters, and (5) responsiveness to regional-specific employment hubs. This research demonstrates a practical method for leveraging labor market data to inform curriculum planning and highlights the potential of ASEAN universities to develop WIL programs that provide students with more meaningful, industry-relevant learning experiences.

Keywords: ASEAN ICT Skills, ICT education, job analysis, curriculum alignment, text mining.

The rapid growth of the information and communication technology (ICT) sector has reshaped global labor markets, increasing the demand for digitally skilled professionals across all industries. Global ICT spending was projected to reach USD 5.6 trillion by 2025, driven by exponential growth in areas such as artificial intelligence (AI), cloud computing, and cybersecurity (Sherif, 2025). In Asia, the pace of digital transformation continues to accelerate. According to Statista (2025), the region's internet economy is expected to grow from USD 263 billion in 2024 to USD 295 billion by 2025. Association of Southeast Asian Nations (ASEAN) countries such as Singapore, Malaysia, and Indonesia have emerged as regional digital leaders, supported by national policies that integrate ICT into broader economic development agendas (Ha & Chuah, 2023).

Despite this rapid growth of the digital economy, a critical challenge remains: the persistent mismatch between ICT education and labor market needs. Higher education institutions in ASEAN continue to struggle to produce graduates with the cross-functional and technical skills required by industry (Suresh, 2024; Tan & Tang, 2016). Nithithanatchinnapat and Joshi (2019) identified significant skills gaps in areas such as network security, system integration, and cloud computing, which are essential for enhancing national competitiveness.

The rapid growth of the ASEAN ICT sector has created various challenges, particularly in industries driving digital transformation. According to an analysis by Cisco and Oxford Economics (2018) the ASEAN-6 countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam) are projected to lose up to 6.6 million jobs to automation by 2028, while only 1.6 million new jobs are expected to be created in the digital industry. This imbalance has resulted in significant regional skills

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gaps, forcing companies to address pressing workforce challenges (Abiodun et al., 2023). However, many educational programs have been slow to adapt their strategies to meet evolving workforce demands, especially in fast-growing sectors such as AI, data analytics, and digital governance.

To address these issues, the ASEAN ICT Skills Standard was established as a regional framework aimed at standardizing ICT skill definitions and promoting labor mobility (ASEAN Secretariat, 2015; Office of the National Digital Economy and Society Commission [ONDE], 2022). The framework outlines 10 core skill areas and corresponding sub-roles that can guide curriculum development and support the mutual recognition of qualifications across member states. Nevertheless, recent research indicates that these frameworks are not yet widely implemented in recruitment systems or higher education institutions (Pinprayong, 2015; Zhang et al., 2023).

Work-integrated learning (WIL), grounded in experiential learning theory (Kolb, 2014), serves as an effective approach to addressing this gap. WIL is a pedagogical methodology that integrates industry-relevant experiences and professional practices into educational frameworks to enhance employability (Zegwaard et al., 2023). In ICT education, WIL helps students adapt to rapidly evolving technological domains. Within the ASEAN higher education context, WIL commonly takes the form of industry placements, cooperative education, project-based collaborations, or hybrid models that combine coursework with professional engagement. The structure of WIL varies across countries and institutions. Some programs require compulsory internships as part of degree requirements, while others offer optional or credit-bearing project-based modules. The intensity of WIL also differs across ASEAN. For example, in Singapore, most ICT degrees include a compulsory placement lasting three to six months, whereas in Malaysia and Thailand, shorter internships of eight to twelve weeks are common. In Indonesia and Vietnam, WIL is often optional or credit-bearing, typically equivalent to three to six credits. These variations indicate that while WIL is widely implemented, its structure depends heavily on national and institutional contexts. Despite this diversity, a common emphasis lies in linking academic learning with industry-relevant experience, positioning WIL as a bridge between university curricula and the rapidly evolving ICT labor market in ASEAN. However, effective WIL design requires real-time labor market intelligence, which is largely absent from current research on ASEAN curriculum design systems (Garant-Jones et al., 2024).

Integrating computational analysis is essential for advancing WIL. Techniques such as term frequency-inverse document frequency (TF-IDF) and cosine similarity, part of natural language processing (NLP), have been applied in educational analytics to classify job roles and identify emerging skill patterns (Qaiser & Ali, 2018; Tata & Patel, 2007). These methods provide scalable, data-driven approaches for mapping unstructured job descriptions to structured role profiles, enabling more responsive educational planning (Januzaj & Luma, 2022; Lahitani et al., 2016). Nevertheless, few scholars have applied these methods within ASEAN-specific skill frameworks, highlighting a critical gap in both practical implementation and policy development.

This study addresses this gap by applying TF-IDF and cosine similarity to a dataset of 4,443 LinkedIn job postings from ASEAN countries, systematically mapping them to sub-roles defined in the ASEAN ICT Skills Standard. Building on this foundation, the study examines how real-time ICT job postings across ASEAN can be aligned with the ASEAN ICT Skills Standard to identify patterns that inform the design of WIL programs. The research focuses on understanding the distribution of ICT roles, variations across countries, and the implications these trends hold for developing adaptable WIL strategies. Three guiding research questions are proposed:

1. How can text analysis tools efficiently map diverse job descriptions to the ASEAN ICT Skills Standard?
2. What is the current distribution of key ICT skill areas across ASEAN countries?
3. How can insights from job posting analysis improve the alignment of WIL programs with the needs of the ASEAN ICT sector?

By addressing these questions, this study contributes to the development of evidence-based strategies for WIL reform. The proposed integrated model creates a direct link between educational planning and real-time labor market trends, enabling institutions to equip students with the essential skills needed to navigate the rapidly changing digital economy of Southeast Asia.

LITERATURE REVIEW

ICT Labor Market Trends in ASEAN and Globally

The digital transformation of the global economy has led to significant changes in labor market requirements, particularly in the ICT sector. Schwab and Zahidi (2020) project that automation and emerging technologies will eliminate 85 million jobs worldwide by 2025, while simultaneously creating 97 million new positions better aligned with digital systems. These shifts necessitate restructuring job roles and prioritizing large-scale upskilling initiatives. In the Asia-Pacific region, the transformation is especially rapid. Grand View Research (2024) estimates that the region's ICT services market reached USD 364.6 billion in 2023 and will grow at a compound annual growth rate (CAGR) of 11.10% between 2024 and 2030. While these projections highlight strong opportunities, the demand for ICT talent has already outpaced supply. Sherif (2025) predicts that global ICT investment will exceed USD 5.6 trillion by 2025, with particularly high demand for expertise in cybersecurity, cloud solutions, and AI.

ASEAN countries are actively embracing digital progress, but the speed and scale of advancement vary significantly. According to Statista (2025), ASEAN's internet economy is expected to grow from USD 263 billion in 2024 to USD 295 billion in 2025. Ha and Chuah (2023) attribute this growth largely to national digital strategies, such as Singapore's Smart Nation and Malaysia's MyDIGITAL, which aim to integrate ICT infrastructure, services, and workforce planning (Ministry of Digital, 2025; Smart Nation and Digital Government Office, 2020;). However, the distribution of this growth is uneven. Box and Lopez-Gonzalez (2017) note that advanced digital infrastructure and stronger governance policies in countries like Singapore and Malaysia have allowed them to outperform less developed nations such as Cambodia and Laos. Similarly, Tan and Tang (2016) argue that the lack of coordinated education-industry collaboration in several ASEAN countries has hindered systematic ICT workforce development. A major concern remains the persistent shortage of trained ICT professionals. Nithithanatchinnapat and Joshi (2019) identify critical gaps in areas such as system administration, cloud engineering, and cybersecurity, even in relatively advanced economies like Thailand and Indonesia.

Cisco and Oxford Economics (2018) provide a sobering projection: the ASEAN-6 countries may experience a net loss of 6.6 million jobs to automation by 2028, with only 1.6 million new digital roles expected to emerge. Large enterprises also face a shortage of workers with strong information management capabilities (Kolding et al., 2018). This imbalance poses a significant threat to regional competitiveness. There is also a structural mismatch between entry-level and specialized roles. While user support and network administration positions are relatively abundant, demand for highly specialized roles such as cloud architects and AI engineers has risen sharply (Grand View Research,

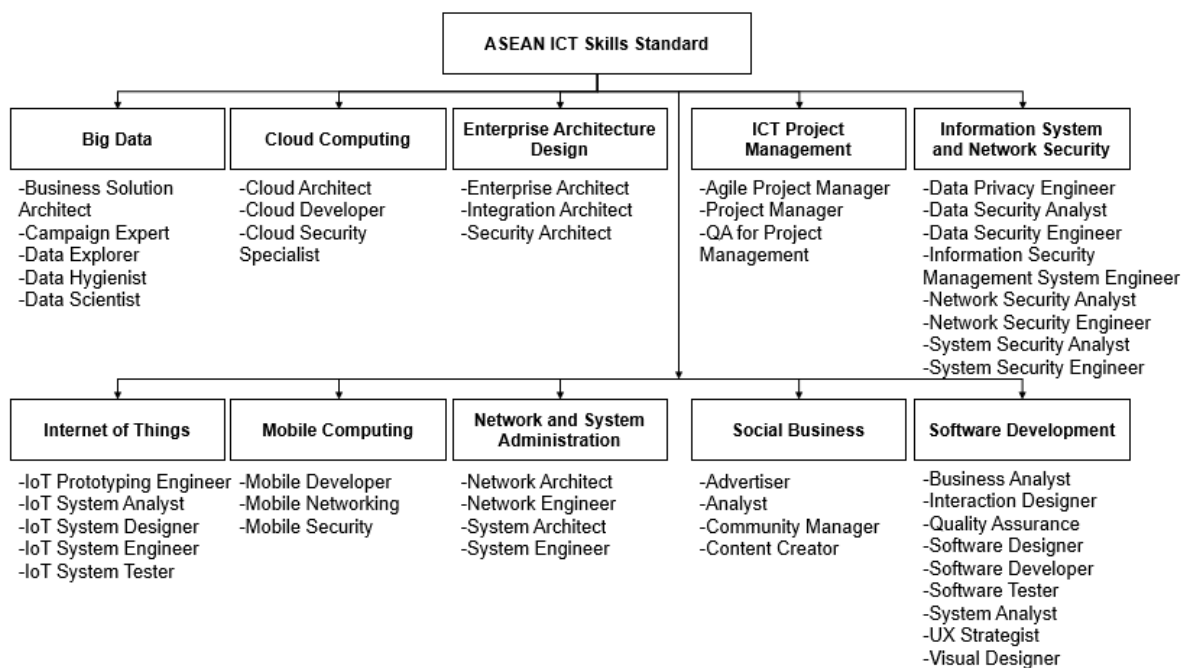
2024). Moreover, digital positions increasingly require transdisciplinary competencies, including business intelligence and risk management (Jafari-Sadeghi et al., 2021).

Despite the urgent demand, many ASEAN higher education institutions still rely on traditional education models. Chou and Yu (2020) argue that rigid curricula and limited employer collaboration hinder timely adaptation to labor market shifts. These findings align with Suresh (2024), who reports that most higher education institutions in the region struggle to meet evolving industry requirements. Although ASEAN's digital economy is expanding rapidly, workforce development remains a critical challenge. Ultimately, ASEAN's digital success depends not only on infrastructure investment but also on education systems capable of preparing graduates with job-ready skills.

ASEAN ICT Skills Standard

The ASEAN ICT Skills Standard provides a core framework for defining, assessing, and recognizing ICT skills across ASEAN member states (ONDE, 2022). It establishes a standardized skills structure to support cross-border ICT certification recognition and promote regional workforce mobility. The framework defines 10 essential ICT skill areas that are critical for sustaining a digital economy. These areas include big data, cloud computing, enterprise architecture design, ICT project management, information system and network security, internet of things (IoT), mobile computing, network and system administration, social business, and software development. Each core skill area is further subdivided into sub-roles, representing specialized functions. For example, software development includes sub-roles such as business analyst, systems analyst, software tester, and quality assurance specialist. These sub-roles provide clear guidelines that enable employers to measure workforce competencies and align organizational needs with role-based expectations. Figure 1 illustrates the overall structure of the framework, demonstrating how core skills are translated into job-relevant roles and tasks. It is based on the *ASEAN ICT Master Plan 2020* (ASEAN Secretariat, 2015) and the *ASEAN ICT Skills Standard 2018* (ONDE, 2022).

FIGURE 1: Core ICT skill areas and sub-roles defined in the ASEAN ICT Skills Standard.



To maximize the benefits of the skills standard, stakeholders can apply the framework in real-world contexts. For instance, universities can align curricula with industry-defined competencies and incorporate role-based learning into their programs (Hong & Songan, 2011). Employers can use the framework to create job descriptions, design training programs, and recruit talent based on standardized role profiles (Siddoo et al., 2019). At the policy level, governments are encouraged to integrate the framework into national qualification systems and cross-border labor migration initiatives (Wongwuttawat, 2016).

Despite its comprehensive design, practical implementation of the framework remains limited. Most applications to date have been descriptive or aspirational, with few empirical efforts to systematically map real-time labor market data to the framework. According to Zhang et al. (2023), the lack of integration in operations, particularly in digital curriculum design and workforce analytics, represents a missed opportunity for innovation in both education and policy. Similarly, Tan and Tang (2016) highlight the persistent gap between educational institutions and labor market policies, emphasizing the need for a more data-driven, operational paradigm. To address these structural challenges, researchers have increasingly focused not only on understanding the state of ICT skills demand but also on developing methods for analyzing and classifying labor market data.

Curriculum–Industry Misalignment and the Role of Work-Integrated Learning

One of the most significant challenges in ASEAN ICT education is the persistent misalignment between academic curricula and the rapidly evolving demands of the labor market. Traditional degree programs are often insufficiently adaptive to equip graduates with the practical skills required by employers. This issue is driven by the increasing specialization of ICT roles, which now encompass diverse and highly technical domains (Abiodun et al., 2023; Chou & Yu, 2020). This disconnect has been identified as a major contributor to graduate unemployment and underemployment in the region (Poncio, 2024; Suresh, 2024).

Drawing on Kolb’s (2014) experiential learning theory, WIL has emerged as a key strategy for addressing workforce challenges. WIL integrates academic instruction with real-world professional experiences, enabling learners to engage directly with industry problems, tools, and expectations. Through this approach, WIL bridges the gap between theoretical learning and work readiness (Zegwaard et al., 2023). Recent studies emphasize that when WIL programs are closely aligned with current labor market demands, they can significantly enhance graduates’ employability (Mabungela & Mtiki, 2024; Rowe & Zegwaard, 2017).

While the value of WIL is widely recognized, its practical implementation has been called into question. Fortino et al. (2019) argue that many WIL programs lack structure and fail to establish systematic connections with curriculum planning or workforce forecasting. Similarly, McNamara (2013) cautions that without sustained collaboration between academia and industry, as well as continuous curriculum updates, WIL initiatives risk becoming largely symbolic, offering work experience without producing meaningful skill development. Another major concern is that most WIL designs are informed by outdated or incomplete data (Fleming & Zegwaard, 2018). Employer surveys and academic feedback often focus on past requirements rather than emerging trends. Moreover, recent research highlights that the rapid pace of technological innovation demands the use of real-time labor market data. This approach shifts attention from job titles to specific job tasks and competencies, providing a more precise mechanism for linking educational curricula to industry needs (Carnevale et al., 2014; Müller et al., 2023).

In summary, WIL offers a valuable foundation for bridging the gap between education and employment, but its effectiveness depends on stronger alignment with dynamic labor market data (Belloum et al., 2019; Guo et al., 2016). This underscores the importance of methodological innovations that can deliver role-specific, data-driven insights—a focus explored in the following section.

Using NLP and Text Mining in Labor Market Analysis

One effective way to strengthen WIL and improve curriculum alignment is through computational approaches. NLP and text mining techniques can analyze job postings and connect them to structured skill frameworks, providing educators with a clearer understanding of both general and specialized industry requirements (Guo et al., 2016). This approach allows WIL programs to evolve beyond traditional simulations and internships, creating more customized, role-based learning environments that reflect real-world job requirements.

NLP and text mining techniques have become increasingly prominent in educational and labor market research, offering innovative methods for analyzing job demand patterns, tracking skill trends, and aligning competencies with workforce needs (Mezhoudi et al., 2023; Qaiser & Ali, 2018). Unlike traditional keyword matching or manual expert classification, NLP can be scaled and automated to process large volumes of unstructured text data, such as job postings and résumés, making it particularly valuable in dynamic and multilingual contexts (Khaouja et al., 2021).

Among these techniques, TF-IDF has been widely used to determine the relative importance of words within a document compared to a larger corpus (Tata & Patel, 2007). In job analysis, TF-IDF helps identify specific terms that distinguish one job description from another by applying numerical measures to detect relevant skills or roles (Guo et al., 2016). When combined with cosine similarity, a metric that measures the angle between two TF-IDF vectors, researchers can calculate the similarity between job postings and predefined role descriptions within a skill framework (Lahitani et al., 2016).

Several studies have demonstrated the utility of these methods in workforce analytics. For example, Qaiser and Ali (2018) applied TF-IDF and cosine similarity to analyze academic research trends, showing that keyword relevance and document similarity can be effectively used to classify topics. Later, Januzaj and Luma (2022) extended these techniques to map job advertisements to the European competency framework, finding that semantic similarity approaches were more accurate in predicting role alignment compared to traditional classification methods.

However, in the ASEAN region, such computational approaches remain underutilized. Most labor market studies continue to rely heavily on surveys and expert interviews, which are time-consuming and limited in scope (Papoutsoglou et al., 2019). This lack of automation hinders the ability of universities and policymakers to respond quickly to rapidly shifting labor demands. Moreover, job portal data in ASEAN countries are often multilingual and unstructured, requiring efficient preprocessing and analytical techniques to ensure accurate interpretation (Poonnawat et al., 2019).

Putka et al. (2023) demonstrated that NLP can streamline job analysis by rapidly extracting required skills and competencies from job descriptions. This approach enables educational institutions to gain timely insights for curriculum improvement and to respond proactively to labor market needs. Furthermore, NLP-based analysis minimizes reliance on subjective human judgments, reducing bias and enhancing the reliability of workforce planning data.

Conceptual Frameworks for Education-to-Employment Alignment

Aligning educational outcomes with employment needs has become a critical challenge in today's era of rapid technological change and globalization. Scholars and practitioners across both developed and developing countries emphasize the need for education systems to be more agile, data-driven, and responsive to evolving labor market demands (Fortino et al., 2019; Januzaj & Luma, 2022; Zhang et al., 2023). In the ICT sector, innovation frequently outpaces curriculum reform, leading to a persistent mismatch between graduate competencies and industry expectations.

One promising approach is the education-to-employment process model, which emphasizes alignment among teaching practices, skill development, and labor market needs (Tyson & Zysman, 2022). This alignment can be strengthened by skill-based frameworks such as the European e-CF and ESCO and, in the ASEAN context, the ASEAN ICT Skills Standard. These frameworks provide taxonomies of roles and competencies that can support curriculum design and regional workforce mobility (ONDE, 2022). However, without tools to operationalize them in real time, these frameworks remain largely theoretical and underutilized (Aničić et al., 2016; Guo et al., 2016).

Recent literature suggests two key strands of research. First, studies highlight ICT workforce trends and critique the limitations of WIL as a pedagogical bridge. Without timely labor market data, WIL risks reinforcing outdated practices instead of preparing students for emerging roles. Second, research demonstrates the potential of computational methods, such as NLP, TF-IDF, and cosine similarity, for role classification and skills mapping. However, most applications of these methods have been concentrated in Europe and North America, with limited exploration within the ASEAN skills framework.

These perspectives reveal a clear research gap. While the ASEAN ICT Skills Standard provides a unified framework, it has not yet been systematically integrated with computational methods or real-time workforce data. This study addresses this gap by exploring the following question: how can computational text-mining methods be used to link real-time ICT job postings in ASEAN to the ASEAN ICT Skills Standard, and what insights can this provide for aligning higher education curricula and WIL programs with labor market needs?

By applying TF-IDF and cosine similarity to a large dataset of job postings, this research contributes in two ways. Methodologically, it demonstrates a replicable model for operationalizing skill frameworks. Substantively, it offers evidence-based insights for curriculum renewal, WIL design, and regional workforce planning within ASEAN.

METHODOLOGY

Research Design

This study employs computational text analysis to examine the alignment between ICT job advertisements and the ASEAN ICT Skills Standard. The design integrates quantitative analysis of large-scale job posting data with qualitative expert validation to ensure the reliability and practical relevance of the results. The research process is structured into three main phases: (1) data collection, (2) text preprocessing, and (3) semantic role mapping using TF-IDF and cosine similarity.

Data Collection

The dataset consists of 4,443 unique ICT job postings collected from LinkedIn in February 2025. LinkedIn was selected as the data source because of its widespread use in professional recruitment and its consistent data structure, which facilitates computational analysis (Zhang et al., 2023). Only postings originating from ASEAN countries and tagged under ICT-related categories were included. The keywords 'IT' and 'ICT' were used to identify relevant job postings, with the search restricted to 10 ASEAN countries as potential work locations.

For the final analysis, the study focused on six digitally advanced ASEAN countries: Singapore, Malaysia, the Philippines, Thailand, Indonesia, and Vietnam. These countries collectively represent the majority of ICT-related hiring activity in the region, based on prior digital economy benchmarks (Ha & Chuah, 2023). Posts from digitally less-developed countries such as Laos, Brunei, Cambodia, and Myanmar were excluded due to data sparsity. To ensure semantic consistency and comparability, only English-language job descriptions were analyzed. Postings originally written in other languages were translated into English using a reliable machine translation tool before processing.

The study concentrated on full job descriptions, deliberately excluding job titles to avoid inconsistencies arising from diverse naming conventions among employers. Postings containing incomplete information, duplicate entries, or non-ICT roles were systematically removed during data cleaning. The final corpus encompasses a broad spectrum of ICT roles and job levels, ranging from entry-level technical support positions to senior systems architect roles. It provides a comprehensive view of the region's ICT labor market.

Text Preprocessing

Standard NLP preprocessing steps were applied to the dataset, including lowercasing, tokenization, stopword removal, and lemmatization. These steps ensured that all job postings were standardized for comparison and helped reduce noise that could interfere with semantic matching (Fortino et al., 2019).

Semantic Role Mapping Using TF-IDF and Cosine Similarity

The ASEAN ICT Skills Standard served as the benchmark for job role classification (ONDE, 2022). The framework defines 10 core skill areas, which are further divided into 47 sub-roles. Descriptions of these sub-roles were extracted and converted into plain-text reference vectors, providing a structured basis for semantic similarity comparisons with job postings.

TF-IDF Vectorization and Cosine Similarity

As discussed in Section 2, TF-IDF highlights distinctive terms within a document relative to the broader corpus. In this study, TF-IDF was applied to both job descriptions and sub-role descriptions from the skills framework, generating numerical vectors that represented the unique emphasis of each text. Cosine similarity was then computed to compare these vectors, with the degree of similarity measured by the angle between them. This method enabled fair comparisons between job postings of varying lengths. Each job posting was assigned to the sub-role with the highest similarity score, ensuring a data-driven classification process. This two-step process produced a role classification system that not only reveals labor market trends but also provides a practical foundation for aligning WIL modules, internships, and project-based courses with real-time industry demands.

Validation and Accuracy

To assess the accuracy of the classification model, a random sample of 150 job postings was manually reviewed by two ICT domain experts. Each expert independently assigned the job descriptions to one of the 47 sub-roles defined in the ASEAN ICT Skills Standard. The classifications from both experts were then compared to the TF-IDF model's assignment.

The model achieved a 93% match rate, indicating a high level of reliability. Most discrepancies were observed in job postings that contained unclear descriptions or multiple overlapping tasks, which created challenges for both the model and the human reviewers in determining a single dominant sub-role.

Ethical Considerations

All data used in this study were publicly available job postings and contained no personally identifiable information. There was no direct interaction with job seekers or employers. The research followed standard data ethics principles, including informed secondary use and respect for platform terms of service. All records were stored in encrypted storage and analyzed in aggregate form.

RESULTS

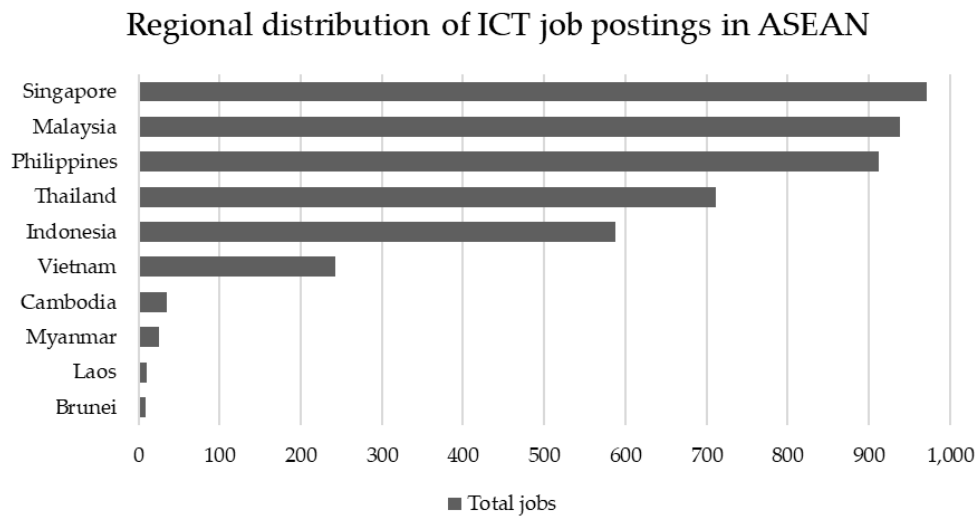
This section presents the findings from the text analysis of 4,443 ICT-related job postings collected from 10 ASEAN countries. The results are organized into four thematic areas: (1) geographic distribution of job postings, (2) skill area classification, (3) sub-role matching and specialization, and (4) emerging patterns and role clustering. Each subsection provides descriptive statistics followed by an initial interpretation of the trends.

Geographic Distribution of Job Postings

As shown in Figure 2, job postings were unevenly distributed across the ASEAN region. The top three contributors—Singapore (21.85%), Malaysia (21.11%), and the Philippines (20.53%)—accounted for over 63% of the total postings. The remaining share was distributed among Thailand (16.03%), Indonesia (13.23%), and Vietnam (5.47%).

This concentration reflects known regional digital disparities. Singapore's high proportion aligns with its advanced digital economy, while Malaysia and the Philippines benefit from their roles as regional hubs for ICT outsourcing and shared services. In contrast, countries such as Cambodia, Myanmar, Laos, and Brunei were significantly underrepresented, contributing fewer than 50 postings each. Due to this data sparsity, these countries were excluded from the semantic analysis in the subsequent stages of the study.

FIGURE 2: Regional distribution of ICT job postings in ASEAN.



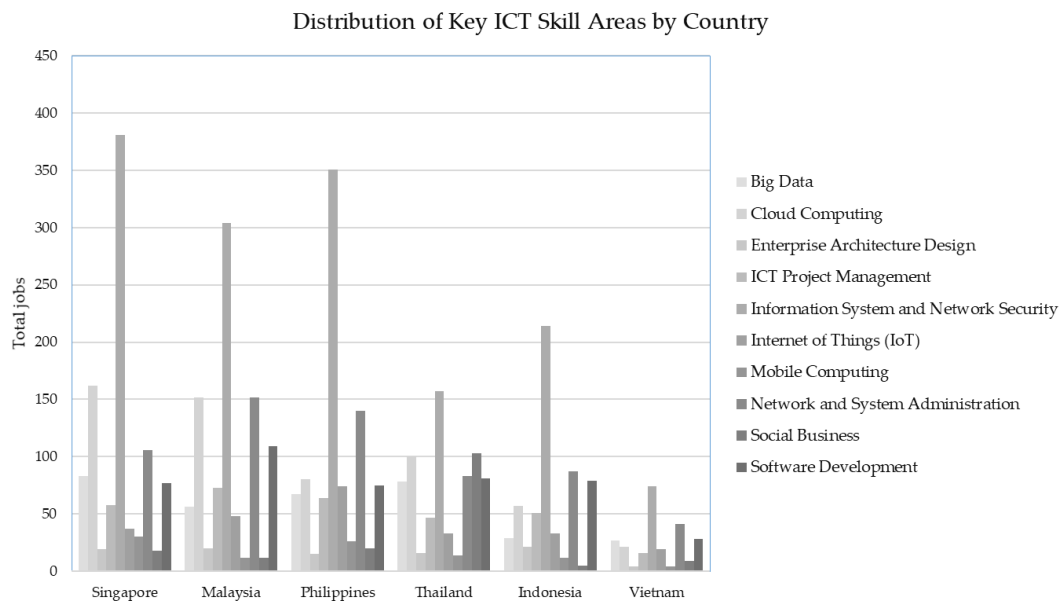
Skill Area Classification

The ASEAN ICT Skills Standard defines 10 core skill areas. Each job posting in this study was assigned to one primary skill area using TF-IDF and cosine similarity. Figure 3 displays the aggregated counts of job postings per skill area across the region.

Information systems and network security emerged as the most dominant domain, accounting for 25% of all classified postings. The next most common areas were software development (19%) and cloud computing (16%). Other domains, such as social business (9%), IoT (7%), and mobile computing (4%), showed moderate representation. The distribution of these skill areas varied significantly across ASEAN member countries. For example, Thailand reported the highest percentage of social business-related postings (14.4%), while the Philippines showed minimal emphasis on IoT roles (11.2%). Singapore exhibited a balanced distribution, with strong representation in cloud computing, network security, and corporate architecture.

These results suggest that while regional integration through frameworks such as the ASEAN ICT Skills Standard is valuable, country-specific strategies and industry priorities continue to play a critical role in shaping ICT workforce readiness.

FIGURE 3: Distribution of key ICT skill areas by country.



Sub-Role Matching and Specialization

Each job was assigned to one of the 47 sub-roles defined by the ASEAN ICT Skills Standard. The top 10 most frequently matched sub-roles are presented in Table 1.

The distribution of ICT job sub-roles across ASEAN countries indicates a strong market demand for expertise in security and infrastructure. As shown in Table 1, cloud security specialists, system engineers, and network security engineers highlight the industry's emphasis on digital security infrastructure and the management of complex systems. Data-oriented roles, such as data scientists and data security analysts, also appear in the top ten, underscoring the growing importance of data governance and analytics in the region. Furthermore, project management and business analysis roles are becoming increasingly significant, suggesting that ICT positions increasingly require a blend of technical expertise and managerial skills.

TABLE 1: Top 10 matched sub-roles across ASEAN job postings.

Rank	Sub-Role	Total jobs
1	Cloud Security Specialist	506
2	System Engineer	440
3	Network Security Engineer	352
4	System Security Engineer	328
5	Information Security Management System Engineer	320
6	Data Scientist	252
7	QA for Project Management	210
8	Business Analysis	175
9	Software testing	133
10	Data Security Analyst	131

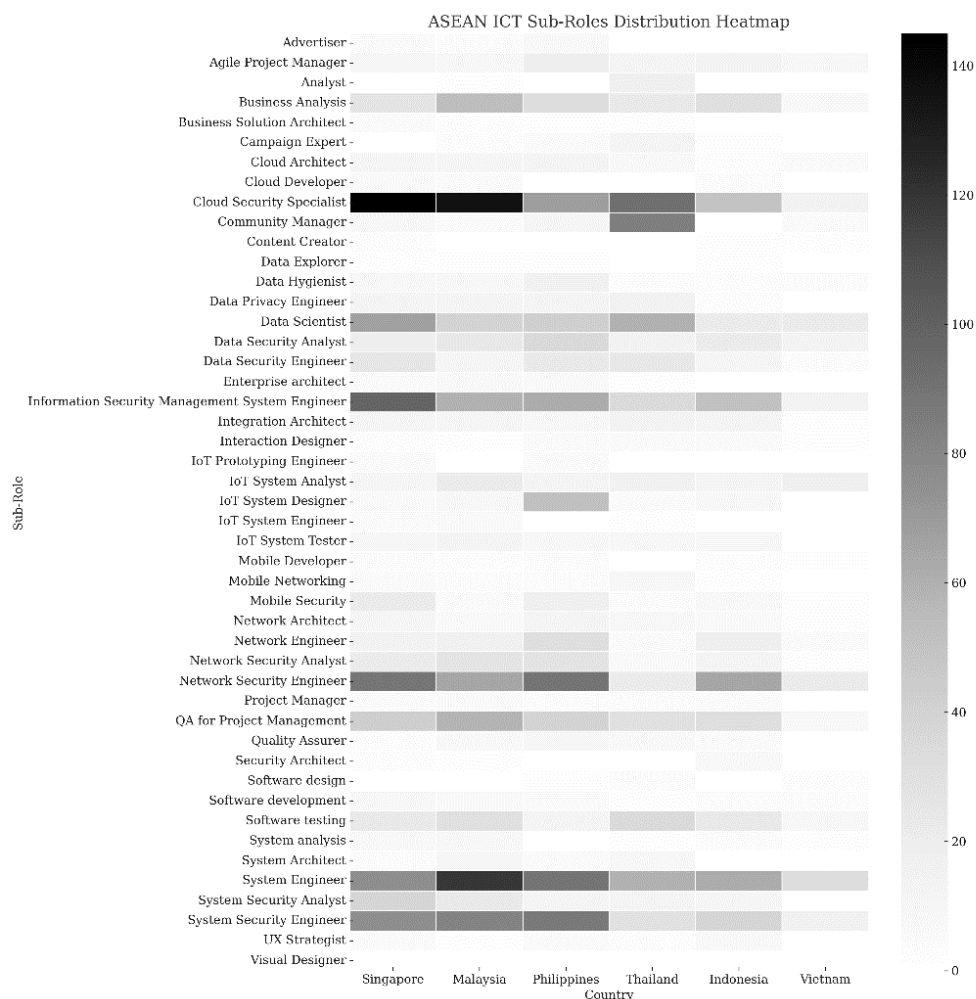
Emerging Patterns and Role Clusters

To provide a clearer view of country-specific job trends, the heatmap is presented in Figure 4. The ASEAN ICT labor market reveals distinct national orientations in role specialization. Singapore demonstrates a mature and well-balanced ecosystem, with strong demand for roles that integrate security, cloud infrastructure, enterprise systems, and compliance. This pattern aligns with Singapore's position as a leader in digital governance, though the study identifies correlation rather than direct causation. Malaysia exhibits a concentrated focus on engineering-intensive and cybersecurity roles, reflecting a workforce oriented toward infrastructure deployment, technical operations, and quality assurance.

In contrast, the Philippines displays a notable concentration in IoT-related and ICT support roles, suggesting alignment with global service delivery and embedded systems integration. Thailand shows a socially and business-oriented cluster, where community engagement and platform-driven roles dominate, consistent with its consumer-centric digital economy. Indonesia demonstrates a broad-based pattern with moderate activity across several technical domains, reflecting a strategy centered on foundational digital capacity building rather than niche specialization. Meanwhile, Vietnam demonstrates emerging strengths in software integration, analytics, and IoT systems, aligned with its growing role in regional software outsourcing and SME digitization.

Across the region, security-related roles remain dominant. However, newer specializations, such as IoT, community management, and agile delivery, are gaining traction in specific countries. These evolving patterns reflect a regional digital landscape that is simultaneously diversifying and stratifying, shaped by national priorities, economic structures, and workforce readiness.

FIGURE 4: ASEAN ICT sub-roles distribution heatmap.



DISCUSSION

This section interprets the findings in relation to the study's research questions, drawing on prior literature on ICT labor markets, skills frameworks, and WIL. Each subsection addresses one research question to provide structured insights into the implications of the results.

Research Question 1: How can Text Analysis Tools Efficiently Map Diverse Job Descriptions to the ASEAN ICT Skills Standard?

The application of text analysis methods, specifically TF-IDF and cosine similarity, demonstrated strong potential for mapping unstructured job postings to structured skills frameworks such as the ASEAN ICT Skills Standard. Expert validation revealed that the model achieved a matching rate of 93%, indicating a high level of accuracy in aligning LinkedIn job postings with predefined sub-role descriptions. These findings support the work of Qaiser and Ali (2018) and Januzaj and Luma (2022), who reported that semantic vectorization techniques effectively classify labor market tasks.

While the industry expert approach remains valuable for curriculum design, it is limited in both frequency and scope (Abiodun et al., 2023). In contrast, NLP offers superior scalability and

adaptability, enabling the continuous updating and management of large volumes of labor market data. This capability is particularly beneficial for ASEAN countries, which face challenges such as linguistic diversity and uneven levels of digital development (Lahitani et al., 2016).

Moreover, cosine similarity allows for a more nuanced semantic comparison by going beyond basic keyword matching to capture contextual relationships between terms. This enables the system to differentiate between roles that may appear similar on the surface but differ in functional responsibilities (Mezhoudi et al., 2023). For example, although network administrators and security administrators may use overlapping terminology, they perform distinct operational functions within ICT infrastructures.

By applying this technique to a regional framework, an approach that has been underutilized in empirical studies (Zhang et al., 2023), this research moves the framework from a purely policy-driven tool to a practical, dynamic classification system. This aligns with Siddoo et al. (2019), who advocate for the digitalization of competency frameworks to improve education and recruitment processes. Text analytics thus serves as a bridge between education and employment by providing real-time insights into workforce needs. It enables educators, employers, and policymakers to make more informed and data-driven decisions. This approach directly supports the goals of WIL by narrowing the gap between the skills students acquire and those required by employers. By systematically classifying thousands of job postings into standardized role categories, the TF-IDF and cosine similarity methods allow WIL programs to identify the competencies that should be prioritized in curricula and placements. This, in turn, makes it possible to align student learning activities directly with current labor market demands.

Research Question 2: What is the Current Distribution of Key ICT Skill Areas Across ASEAN Countries?

The study found that the demand for ICT skills across ASEAN countries is characterized by both similarities and differences. Overall, job roles in IT and network security, software development, and cloud computing emerged as top priorities. However, the degree to which each country emphasizes these skill areas varies considerably.

Singapore demonstrated a balanced demand for skills across cloud computing, cybersecurity, and enterprise systems, reflecting its national goal of becoming a smart, digital nation (Ha & Chuah, 2023). Similarly, Malaysia and the Philippines showed strong demand for security and cloud-related roles, but their focus was more heavily weighted toward technical operations rather than leadership positions.

Other countries displayed more distinctive patterns. Thailand exhibited strong demand for social business skills, such as digital marketing and e-commerce. Vietnam, in contrast, emphasized software development and business analysis, supporting its growing role in technology exports. These findings are consistent with earlier studies (Abiodun et al., 2023; Tan & Tang, 2016) that highlight how national strategies and industrial structures shape ICT skill demand in the ASEAN region.

The data also reinforces the notion that ASEAN does not function as a single, unified digital economy. Significant disparities remain in infrastructure, investment, and education (Box & Lopez-Gonzalez, 2017). Consequently, skill development initiatives must be tailored to the specific needs of each country, even when adopting a common reference framework such as the ASEAN ICT Skills Standard. These distributions should be interpreted cautiously, given the current limitations of the framework. While the ASEAN ICT Skills Standard provides a useful reference point, it does not yet fully capture rapidly emerging areas such as AI and blockchain. Moreover, it has not been widely adopted by

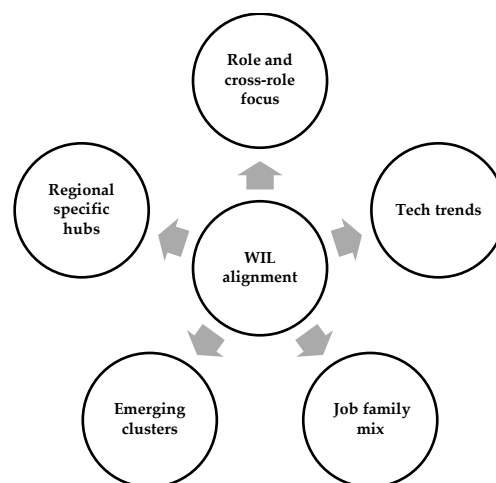
industry or academic institutions. In this study, the framework primarily serves as a structural tool for analysis, but future revisions and stronger industry engagement will be critical to improving its relevance and applicability.

For WIL programs, these findings suggest that one-size-fits-all models are unlikely to be effective. Instead, programs should combine regional standards with real-time signals from local job markets. The text mining approach developed in this study offers a scalable way to continuously monitor these trends, enabling universities to design WIL programs that address both national priorities and regional ICT workforce needs.

Research Question 3: How can Insights From Job Posting Analysis Improve the Alignment of WIL programs With the Needs of the ASEAN ICT Sector?

The study's findings highlight the critical role of data-driven job analysis in aligning WIL programs with labor market needs across the ASEAN region. The visualization presented in Figure 5 provides a strategic model for guiding WIL program redesign through five practical alignment strategies: (1) role- and cross-role focus, (2) alignment with emerging technological trends, (3) diversification across job families, (4) identification of emerging skill clusters, and (5) responsiveness to regional-specific employment hubs.

FIGURE 5: Five strategic directions for aligning WIL with ASEAN ICT job demands.



First, WIL programs should move toward role-based curriculum design. Instead of offering general ICT training, programs need to prepare students for specific key roles such as cloud security specialist, network engineer, and business analyst. While role-focused training fosters specialization, cross-role focus emphasizes transferable skills that apply across multiple positions. For example, competencies in communication, project management, and cybersecurity principles are required in many ICT roles. These transferable skills enable students to adapt to diverse jobs and career paths as industry needs evolve. Aničić et al. (2016) and Rowe and Zegwaard (2017) emphasize that clear alignment between learning outcomes and industry-defined roles significantly enhances graduates' employability prospects.

Second, emerging sectors, including cloud computing, cybersecurity, and IoT, are becoming increasingly important. Educators should adapt WIL curricula to reflect these trends (Schwab & Zahidi, 2020; Sherif, 2025). Incorporating real-time labor market analytics can help institutions

integrate cutting-edge techniques into WIL programs, improving their capacity to keep pace with rapid technological and market changes.

Third, the programs should be designed to include a diverse range of job families beyond core technical skills. Many contemporary ICT roles involve cross-functional tasks that require a blend of technology, business, and communication competencies. For instance, the growth of social business jobs in Thailand illustrates this trend. Guo et al. (2016) and Jafari-Sadeghi et al. (2021) highlight the value of developing hybrid skills in ICT education through the integration of data analysis, project management, and digital marketing.

Fourth, early detection of emerging role clusters can inform proactive training and workforce preparation. Distinct national specializations are clearly taking shape: Thailand is experiencing high growth in social business and digital community roles, the Philippines is concentrating on IoT systems and embedded technologies, Vietnam is strengthening its capabilities in software development and analytics, and Malaysia is reinforcing its expertise in engineering and cybersecurity. These trends align with earlier observations by Box and Lopez-Gonzalez (2017), underscoring the need for WIL programs to anticipate sectoral growth rather than respond reactively. Institutions that align their training with national development strategies can better prepare students for future employment opportunities.

Fifth, promoting regional mobility through hub-based WIL design is critical. As ASEAN economies develop sector-specific strengths, cross-border labor mobility becomes increasingly important. The ASEAN Qualifications Reference Framework (ASEAN Secretariat, 2015) supports this goal by fostering reciprocal recognition of skills and qualifications. Enhancing WIL programs will require collaboration among ASEAN member states. For example, Malaysia could serve as a hub for infrastructure engineering and systems security, while the Philippines specializes in IoT services and embedded systems. Vietnam could lead in software integration, Thailand could mentor business-related expertise, and Singapore could take the lead in cloud computing and cybersecurity. Establishing these cooperative centers would enable cross-border internships, collaboratively designed WIL modules, and regional certification pathways aligned with national expertise.

The five strategies are intended to enhance existing WIL formats, such as placements, projects, and hybrid models, particularly those involving direct industry engagement. For instance, role- and cross-role focus can be embedded in project-based learning, while regional mobility strategies can be implemented through cross-border placements or collaborative modules across ASEAN universities. These strategies are designed to be flexible, allowing institutions to adapt them within their existing WIL structures rather than imposing a single uniform model.

For universities, these findings provide an evidence-based foundation for revising WIL curricula to reflect real-time labor market demands. Embedding role-specific competencies into internships or project-based modules ensures that students acquire the precise skills employers are actively seeking. For students, this alignment results in WIL experiences that are both authentic and strategically targeted, improving employability and fostering confidence in the transition to the workforce. By integrating regional standards with real-time data, institutions can design WIL activities that are locally relevant while also regionally portable, ultimately enhancing workforce mobility within ASEAN.

CONCLUSION

This study investigated the application of text analysis techniques to balance ICT labor market demands with curriculum development in the ASEAN context. By analyzing 4,443 ICT-related job

advertisements across 10 ASEAN nations, the study demonstrated the feasibility of using TF-IDF and cosine similarity to map unstructured labor market data to structured skills standards, specifically, the ASEAN ICT Skills Standard.

The findings make several key contributions. First, the study provides empirical evidence that semantic text analysis can serve as an effective tool for operationalizing skills frameworks. While the ASEAN ICT Skills Standard has been broadly recognized at the policy level, it has rarely been implemented in practice or examined through empirical studies. This research effectively implements the framework in a practical environment, demonstrating the systematic coding of job advertisements based on skill area and sub-role. This process transforms the framework into a dynamic planning tool for curriculum designers, policymakers, and WIL program developers.

Second, the study offers detailed insights into both regional and national patterns of ICT labor demand. While core skill areas such as network security, software development, and cloud computing were consistently important across the region, distinct national specializations also emerged. For example, Thailand showed strong demand for social business roles, Vietnam emphasized full-stack programming and analytics, and the Philippines specialized in IoT-related roles. These findings highlight the necessity for localized curriculum design, even within the broader context of regional harmonization.

Third, the study proposes a five-dimensional strategy for enhancing WIL programs in ASEAN. As outlined in Figure 5, these strategies include role-based curriculum design, trend-driven module updates, diversification across job families, early identification of emerging skill clusters, and regional mobility pathways. Together, these approaches address limitations of current WIL models, which often fail to fully reflect real-time labor market needs.

Theoretically, this research advances the body of knowledge on skills alignment and data-driven curriculum development. It reinforces the argument that agile, data-informed program design must replace static course templates in rapidly evolving digital economies. The study also demonstrates the practical value of NLP tools in monitoring labor market trends, particularly in diverse and fast-changing regions such as ASEAN.

From a practical perspective, this research offers educators and institutions a flexible and reusable approach to workforce-aligned curriculum development. By incorporating labor market data into educational planning, institutions can better align graduate skills with employer demands, improve employability outcomes, and contribute to regional economic growth. This ensures that WIL functions not only as a pedagogical bridge between universities and workplaces but also as a dynamic, evidence-based practice that adapts to continuous changes in the digital labor market.

However, this study has certain limitations. Because the dataset was sourced from LinkedIn, some countries and job sectors may be underrepresented. While TF-IDF and cosine similarity proved useful in this context, they may overlook subtle language nuances that advanced language models, such as transformers, are better equipped to capture. Furthermore, the ASEAN ICT Skills Standard itself may have limitations due to its fixed structure and limited adoption by industry and academia. As a result, it may not fully reflect emerging fields such as AI ethics, blockchain technologies, or low-code development platforms.

For future research, integrating TF-IDF and cosine similarity with more advanced models, such as BERT or GPT, could enhance the depth of semantic matching. Expanding data sources to include local

job boards, employer surveys, and regional HR databases would also provide a more comprehensive view of workforce needs. Finally, making the ASEAN ICT Skills Standard available in a machine-readable format would significantly improve its usability for NLP applications, supporting ongoing innovation in labor market analysis and curriculum alignment.

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The International Journal of Work-Integrated Learning (IJWIL) publishes double-blind peer-reviewed original research and topical issues related to Work-Integrated Learning (WIL). IJWIL first published in 2000 under the name of Asia-Pacific Journal of Cooperative Education (APJCE).

In this Journal, WIL is defined as:

An educational approach involving three parties – the student, educational institution, and an external stakeholder – consisting of authentic work-focused experiences as an intentional component of the curriculum. Students learn through active engagement in purposeful work tasks, which enable the integration of theory with meaningful practice that is relevant to the students' discipline of study and/or professional development (Zegwaard et al., 2023, p. 38).*

Examples of practice include off-campus workplace immersion activities such as work placements, internships, practicum, service learning, and cooperative education (co-op), and on-campus activities such as work-related projects/competitions, entrepreneurship, student-led enterprise, student consultancies, etc. WIL is related to, and overlaps with, the fields of experiential learning, work-based learning, and vocational education and training.

The Journal's aim is to enable specialists working in WIL to disseminate research findings and share knowledge to the benefit of institutions, students, WIL practitioners, curricular designers, and researchers. The Journal encourages quality research and explorative critical discussion that leads to the advancement of quality practices, development of further understanding of WIL, and promote further research.

The Journal is financially supported by the [WILNZ](#), [WACE](#), [WIL Australia](#), and the [University of Waikato](#).

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Types of manuscripts sought by IJWIL are primarily in two forms: 1) *research publications* describing research into aspects of WIL and, 2) *topical discussion* articles that review relevant literature and provide critical explorative discussion around a topical issue. The journal will, on occasions, consider good practice submissions.

Research publications should contain; an introduction that describes relevant literature and sets the context of the inquiry. A detailed description and justification for the methodology employed. A description of the research findings - tabulated as appropriate, a discussion of the importance of the findings including their significance to current established literature, implications for practitioners and researchers, whilst remaining mindful of the limitations of the data, and a conclusion including recommendations.

Topical discussion articles should contain a clear statement of the topic or issue under discussion, reference to relevant literature, critical and scholarly discussion on the importance of the issues, critical insights into how to advance the issue further, and implications for other researchers and practitioners.

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