XÁC ĐỊNH CÁC KỸ NĂNG THIẾT YẾU CHO SINH VIÊN VIỆT NAM TRONG BỐI CẢNH CÁCH MẠNG CÔNG NGHIỆP 4.0 THÔNG QUA PHƯƠNG PHÁP KHAI PHÁ VĂN BẢN

TÓM TẮT

Trong bối cảnh Cách mạng công nghiệp 4.0, nhu cầu về kỹ năng cần thiết của sinh viên tốt nghiệp đang thay đổi nhanh chóng. Khác với nghiên cứu trước đây, nghiên cứu này áp dụng phương pháp khai phá văn bản song ngữ (Tiếng Anh và Tiếng Việt) để so sánh kết quả nghiên cứu hàn lâm với kỳ vọng thực tiễn từ nhà tuyển dụng. Đáng chú ý, kết quả cho thấy kỹ năng mềm, đặc biệt là kỹ năng giao tiếp, tư duy phản biện và sáng tạo, xuất hiện thường xuyên hơn kỹ năng cứng liên quan đến công nghệ. Kết quả nghiên cứu khẳng định tầm quan trọng ngày càng lớn của các kỹ năng mềm định hướng con người trong việc đáp ứng nhu cầu thị trường lao động hiện đại. Các khuyến nghị ưu tiên tập trung vào việc tích hợp kỹ năng mềm vào chương trình giảng dạy, thúc đẩy học tập liên ngành, và tăng cường hợp tác với doanh nghiệp thông qua thực tập và các dự án trải nghiệm.

Từ khóa: *Cách mạng công nghiệp 4.0, khai phá văn bản, kỹ năng, sinh viên*

IDENTIFYING ESSENTIAL SKILLS FOR VIETNAMESE STUDENTS IN THE CONTEXT OF INDUSTRY 4.0 THROUGH TEXT MINING METHOD

ABSTRACT

In the context of Industry 4.0, the demand for essential graduate skills is evolving rapidly. Unlike previous studies, this research employs a bilingual text mining approach (English and Vietnamese) to compare academic findings with employers' practical expectations. The results reveal that soft skills, particularly communication, critical thinking, and creativity, are emphasized more frequently than technology-related hard skills. The findings affirm the growing importance of human-oriented soft skills in meeting the demands of the modern labor market. Priority recommendations focus on integrating soft skills into curricula, promoting interdisciplinary learning, and strengthening collaboration with industry through internships and experiential projects.

Keywords: *Industry 4.0, text mining, skills, student.*

1. INTRODUCTION

The Fourth Industrial Revolution (I4.0), characterized by the rapid advancement of technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data, and others, is driving profound and comprehensive transformations across all facets of life, including economics, society, and culture. This revolution extends beyond mere technological advancements, representing a fundamental shift in how workers live, work, and interact. Amid the rapid and transformative changes of I4.0, businesses worldwide face new challenges, necessitating continuous innovation, enhanced productivity, and adaptation to increasingly stringent market demands. Concurrently, the workforce, particularly students who will soon enter the labor market, must acquire relevant skills to meet the requirements of the digital era. This transformation also underscores the need for workers to upskill and embrace new technologies and knowledge to fulfill the evolving expectations of businesses in this new context. According to projections by the World Economic Forum (WEF), more than half of the global workforce requires retraining due to technological changes, two-thirds of currently critical skills will become obsolete, and one-third of the essential skills needed for jobs will be technology-related abilities that aren't considered necessary for today's roles.[1] This highlights the urgent need to identify core skills that individuals, businesses, and educational institutions must prioritize to develop effective training strategies. A recent study conducted across six provinces in Vietnam explored workers' adaptability to I4.0, revealing that they have, to some extent, responded to these changes.[2] This is a positive signal for Vietnam's labor market in the new context. However, despite these encouraging signs, a thorough examination is needed to determine which skills students should prioritize to succeed in the digital age and which methods are suitable for identifying these skills.

Previous studies in Vietnam have discussed the implications of I4.0 for higher education and emphasized the need to enhance students' employability skills,[3,4] highlighting solutions such as strengthening the linkage between universities and enterprises to increase practical training opportunities. However, these studies have remained mainly at the level of conceptual or opinion-based discussion without employing systematic methods to validate or compare skill requirements. A notable case is provided by Nguyễn et al., who conducted twenty in-depth interviews with experts to validate a higher education quality framework.[5] The limited sample of twenty expert interviews constrains the study's scope. A further limitation is the lack of diversity among the interviewees, as most were university lecturers. While this study provides valuable insights into how skills are embedded within the broader framework of higher education quality, it does not directly address the specific question of what skills Vietnamese students need in the context of I4.0.

The research gap lies in the fact that domestic studies have mainly been descriptive or discursive, with limited empirical scope, while international studies, though larger in scale, are not fully aligned with the Vietnamese context. Moreover, no study has systematically contrasted academic findings with the practical expectations of employers. To address this gap, the present study adopts a bilingual text mining approach, which integrates international scholarly evidence with local employer perspectives. This methodological choice ensures that the findings maintain academic rigor and capture the contextual realities of the Vietnamese labor market in the 4.0 era.

As demonstrated in prior studies, such as those evaluating policy research and management studies, text mining is a reliable technique.[6,7] The primary rationale for selecting this method is its effectiveness in extracting, synthesizing, and analyzing data from diverse online sources, particularly in an era of rapidly growing digital information. Azevedo and Azevedo, in their review of tools and techniques for assessing current trends, noted that generative artificial intelligence (GenAI) is an emerging and promising tool.[8] However, they emphasized that it serves primarily as a supportive tool, with challenges in verifying information sources. This perspective aligns with Kiley, who argued that AI-generated information is challenging to validate.[9] Therefore, to ensure transparency in the research process, data should be collected directly from open and publicly accessible sources, enabling easy verification and replication of results.

2. METHODOLOGY

The research was conducted sequentially through the following key steps (Figure 1): reviewing the original study; searching comparative data sources; performing text mining; and conducting data analysis. Finally, the results from the two sources in English and Vietnamese were compared.

2.1. Review of original study

The initial step involved downloading and reviewing the original research article by Islam to identify the essential skills required for graduates to meet the demands of the I4.0 work environment.[10] The factors collected were the final results confirmed through the analysis conducted in the original study.

Drawing on prior research, the primary study by Islam, published in a Q1 journal, was selected for comparison.[10] This study investigated whether students are prepared to enter the modern labor market and possess the skills and competencies required for I4.0. Data were collected through surveys at public and private universities in Bangladesh, with a model constructed and results validated to produce final findings.

Notable differences exist between Bangladesh and Vietnam. Specifically, comparisons of educational systems highlight disparities in overall infrastructure, with Vietnam's more advanced information technology infrastructure facilitating online education and technology applications in education.[11] Despite these differences, shared challenges in transforming education to meet I4.0 requirements create a comparable research context. Bangladesh and Vietnam are developing nations with similar demographic structures, with a high proportion of young populations,[12] and no significant gender disparities.[13] Both countries also have large student populations in higher education and face pressure to enhance workforce quality to meet I4.0 demands. As emerging Asian economies,[14] their education sectors grapple with challenges in the digital transformation era.[15] Indeed, both nations face the critical task of reforming education systems to equip students with the skills needed for a modern labor market increasingly driven by technology. Islam's study,[10] which assessed students' readiness in Bangladesh for the contemporary labor market and identified necessary skills for new technological demands, is highly relevant to Vietnam, where students face similar requirements in the digital era. These shared challenges outweigh the differences, reflecting common developmental goals.

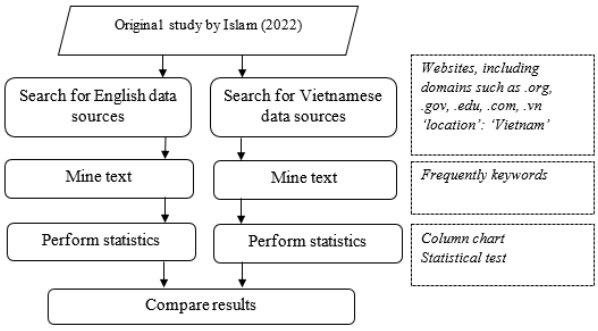

Figure 1. Research steps

2.2. Search for comparative sources

2.2.1. Description of data collection process

Data collection is conducted automatically through search engine queries. The data collection process in this study was performed automatically using the SerpAPI to retrieve information related to the essential skills required for the workforce in the context of I4.0. Specifically, a search query with the keyword "*skills for workforce industry 4.0*" was submitted to Google Search for English-language sources. In contrast, the query "*kỹ năng lực lượng lao động cách mạng công nghiệp 4.0*" was used to identify Vietnamese-language sources, focusing on online information relevant to the Vietnamese context. English-language documents may originate from international websites, organizations, or companies in Vietnam using English to reach a global audience. From this stage onward, Python programming was utilized. The data retrieval timestamp for both sources was recorded as 10:19 on July 8, 2025 (GMT +7). The SerpAPI, a reliable service for retrieving Google search results,[16] was employed to obtain the search results list. The use of automated search methods offers significant advantages over manual searches, particularly in the context of scientific research and large-scale data collection. The results were preliminarily reviewed by randomly skimming the retrieved websites to prevent errors. The data was cleaned before being used for analysis.

2.2.2. Website selection criteria

Information is extracted from official websites, online news outlets, educational institution portals, and research organizations. These sources typically include business insights, technology and training experts, and analyses from reputable organizations. To ensure relevance to the Vietnamese context, the programming code was configured with the parameter "location: Vietnam", prioritizing search results pertinent to Vietnam. The search process was conducted with automatic pagination, collecting 10 results per query, with continuous retrieval thereafter.

To ensure the representativeness and reliability of the collected data, the following filtering criteria were applied: (a) Results from websites with domain extensions .org, .gov, and .edu were prioritized, as these domains typically belong to nonprofit organizations, government agencies, and educational institutions, respectively. (b) This study included only .vn and .com websites employing the HTTPS protocol, which ensures secure data transmission, protects information integrity, and verifies website legitimacy through certification, enhancing the collected data's credibility and reliability. Excluding websites with other domain extensions, such as .vn or .com, was deemed unnecessary, as professional networking platforms like LinkedIn, which fall under these domains, are highly relevant. LinkedIn is a professional platform where experts, organizations, and businesses share information and specialized resources.

2.2.3. Sample size

In text mining, no strict requirement for sample size exists; nevertheless, a commonly accepted principle is that larger datasets are generally preferable. For English-language sources, it was observed that increasing the sample size beyond 300 resulted in a predominance of YouTube videos, rendering text mining less effective; thus, the sample was capped at 300. For Vietnamese-language sources, a sample of 237 data points was collected.

2.3. Text mining

2.3.1 Programming language and library

The content from the selected list of websites was automatically collected using Python programming. Specifically, the websites were accessed through a library named Requests, and the entire content of these pages was retrieved. Subsequently, relevant textual segments, i.e., meaningful text within the articles, were extracted from the HTML content of the websites.

2.3.2. Data cleaning

Following data collection, the retrieved data underwent a series of preprocessing steps to prepare it for further analysis. These preprocessing steps included: eliminating search results that lacked textual content, such as videos or images; standardizing the textual content from the websites by removing special characters, unnecessary punctuation, and converting the text to lowercase. This standardization ensures that keyword counting and subsequent analysis are not affected by variations in capitalization or extraneous characters. During the text mining process, predefined representative keywords (derived from the original list of critical skills for I4.0) were identified and searched within the preprocessed textual content. This step ensures that only content directly relevant to the research topic is retained for further analysis.

2.4. Statistical performance

A list of representative keywords corresponding to critical skills for I4.0 was compiled based on the primary study. The frequency of these keywords was counted within the collected content, enabling the determination of the prevalence of each skill in the analyzed articles. The results were visualized using a frequency chart to directly compare the most frequently mentioned skills. Following the frequency calculation, statistical measures such as standard deviation (Std Dev), t-value, and p-value were analyzed to assess the significance of differences between individual or group skills.

2.5. Result comparison

The results of the analysis of critical skills for I4.0 from the two data sources were aggregated and compared. This process aims to elucidate differences or similarities, with the expectation of providing comprehensive and objective insights.

3. RESEARCH RESULTS

The original study by Islam focuses on identifying the essential skills required for students in the context of I4.0.[10] In this context, the rapid advancement of technology and digitalization fundamentally transforms how individuals work and interact with their environment. Modern organizations require an efficient, flexible workforce prepared to adapt to continuous changes. To meet the demands of the labor market, a diverse set of skills is necessary, as highlighted by Islam.[10] The study identifies the most critical skills for personnel in the digital era: critical thinking, cognitive flexibility, complex problem-solving, adaptive thinking ability, qualitative and quantitative skills, communication, data interpretation, data visualization, virtual collaboration, and creativity. Specifically:

- *Critical thinking:* Critical thinking is evaluating and analyzing issues objectively, grounded in logic and reasoning. This foundational skill enables individuals to comprehend complex problems, identify various solutions' strengths and weaknesses, and make accurate decisions. Critical thinking is essential for processing new information and developing effective problem-solving strategies. Particularly in the era of I4.0, where information flows are increasingly complex, analyzing and processing information efficiently is a decisive factor in an individual's success in the workplace.

- *Cognitive flexibility:* Cognitive flexibility, the ability to adapt to new ways of thinking, is a critical factor in the continuously evolving context of I4.0. As work becomes increasingly complex, requiring the simultaneous resolution of multiple issues and adaptation to abrupt changes, this skill enables workers to seamlessly transition between different tasks and apply varied strategies to address challenges. Cognitive flexibility allows employees to avoid being constrained by rigid thought patterns, instead fostering creative and practical thinking in dynamic and ever-changing situations

- *Complex problem-solving:* Complex problem-solving entails identifying issues and evaluating and devising optimal solutions. I4.0 encompasses advanced technologies such as AI, IoT, big data, robotics, and smart manufacturing. These interconnected systems give rise to new processes and business models while increasing the complexity of management and operations. Addressing these challenges requires systemic thinking skills, considering issues from multiple perspectives, and developing comprehensive solutions.

- *Adaptive thinking:* Adaptive thinking refers to the capacity to adjust to rapid changes in the work environment. In an increasingly volatile labor market, workers must be flexible, ready to adapt to new requirements and continuous technological advancements. It is emphasized that adaptive thinking enables organizations to effectively leverage available resources, thereby enhancing competitiveness and innovation in a global context.

- *Qualitative and quantitative skills:* Qualitative and quantitative skills are critical for analyzing and evaluating information. I4.0 demands the integration of technical disciplines, data science, and management. Qualitative skills involve observing and understanding aspects that cannot be directly measured, such as human behavior, emotions, or societal trends, which technology and machines have not yet fully mastered. In contrast, quantitative skills focus on analyzing numerical data to derive precise and objective conclusions. In the context of I4.0, both skill sets are essential to support effective decision-making processes.

- *Communication:* Communication is an indispensable skill in any work environment, particularly in the era of digitalization. This skill encompasses the clear transmission of information and ensuring that all relevant stakeholders fully understand their objectives

and responsibilities. The authors note that communication skills may vary between technical and non-technical contexts; however, in any situation, the effective conveyance of information consistently plays a pivotal role in the success of a project. Each communication platform has its own rules and cultural nuances. Understanding how to communicate effectively through technological platforms enhances communication efficacy.

- *Data interpretation:* Data interpretation involves analyzing data, deriving meaningful insights, and translating these insights into specific actions. This skill enables businesses to identify trends, uncover hidden data patterns, and make informed decisions based on evidence. I4.0 has ushered in an unprecedented volume of data, generated rapidly from sources such as IoT devices, social media, and online transactions. Data analysis is the key to transforming this vast amount of data into valuable information, enabling organizations and individuals to make more accurate and effective decisions.

- *Data visualization:* Data visualization involves presenting data in charts or other visual tools to facilitate understanding and analysis. This approach enables rapid and straightforward identification of data patterns, allowing focus on content rather than the technological mechanisms, as was common in earlier versions of data visualization tools. Beyond merely analyzing data as numerical statistics, data visualization transforms raw numbers into meaningful insights, enabling businesses to make better-informed decisions and address challenges more effectively.

- *Virtual collaboration:* Virtual collaboration refers to working effectively within remote teams using connective technologies such as video conferencing, document sharing, and other online collaborative tools. Working remotely through technology requires candidates to possess various skills, including planning, proficiency in using technology, and self-discipline in a remote work environment.

- *Creativity:* Creativity generates novel ideas and innovative solutions to complex problems. Innovation extends beyond merely applying new technologies; it requires the workforce to leverage creativity to explore new approaches, develop new products, and establish new processes to meet market demands.

The comparative data sources obtained were diverse. For instance, one source identified was an article titled "10 skills that make you relevant in Industry 4.0",[17] which presents perspectives from a leader of an organization supporting the Indian government in sustainable development through foreign direct investment. Another example is a publication from Deloitte,[18] one of the world's largest accounting and professional services firms by revenue and number of professionals, titled "Critical thinking rivals technical skills for Industry 4.0 success".[18] The comparative data analysis focused on the frequency of mentions of various skills across websites to determine which skills are most critical for graduates, incorporating multidimensional perspectives from leaders, managers, recruiters, and other stakeholders. Each skill mentioned in an article was recorded as a single instance (i.e., regardless of whether the keyword appeared ten times in an article, it was counted as one point).

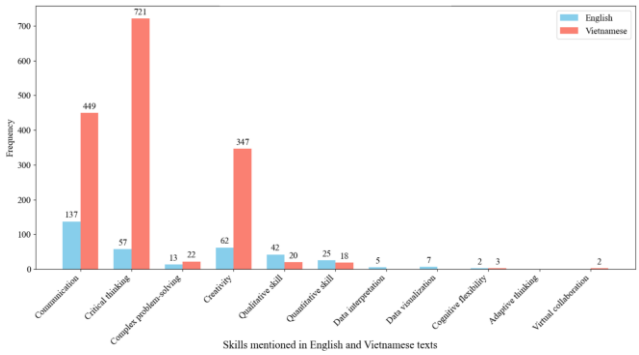

Figure 2. Frequency of keyword occurrences

Findings reveal that the set of essential skills reported in the original study from the Bangladeshi context does not fully emerge in the present analysis (Figure 2); Such variation may be related to contextual differences in labor market demands. The results (Figure 2) indicate that Vietnamese-language articles exhibited a significantly higher frequency of mentions than English-language articles for most skills. Overall, the chart demonstrates a convergence between the two datasets (English and Vietnamese articles) in identifying essential skills, with a particular emphasis on prioritizing soft skills. The discrepancy, specifically the greater volume of Vietnamese search results relative to English, may stem from the Vietnam-specific keywords employed, which inherently limit the number of English-language websites addressing the subject.

Both datasets indicate that soft skills, such as critical thinking, communication, and creativity, are significantly more prominent than hard skills. This underscores the importance of these skills in the era of I4.0, where innovation,

independent thinking, and teamwork are pivotal for success.

Critical thinking emerges as the leading skill when aggregating results from the analysis of both languages, emphasizing its centrality as a foundational skill for developing other competencies, particularly in international collaboration, innovation, and information management within a globalized framework. A recent study published in late October 2024, surveying 400 respondents, including lecturers and students from five universities in Vietnam, highlights that critical thinking must become an essential skill in higher education, playing a crucial role in training a high-quality workforce.[19] However, another study suggests that Asian students,[20] including those in Vietnam, exhibit relatively low levels of critical thinking. Specifically, a survey of final-year nursing students in Vietnam revealed average critical thinking abilities. Consequently, Vietnamese-language sources often prioritize this skill as a call to action for transformative educational and labor market changes. In contrast, English-language sources, targeting a global audience, may consider critical thinking a fundamental and default skill within their educational systems, resulting in less frequent emphasis (ranking second in the English-language analysis). Indeed, the significance of critical thinking is not novel, as Bali notes that numerous researchers have long affirmed its necessity in Western higher education, predating the advent of I4.0.[21]

Communication ranks among the top three skills in both language analyses, securing the second position when combining the results from Vietnamese and English sources. This prominence underscores the high value of interpersonal interaction skills in the modern labor market, particularly in service, technology, and management-related sectors. In the context of I4.0, while technology reshapes how workers operate, effective communication with colleagues, clients, and partners remains a decisive factor for workplace success.

Regarding creativity, the chart (Figure 2) reveals a significant disparity, reflecting widespread interest in fostering innovation and adaptability within Vietnam's evolving economy, which demands creative solutions to compete in the international market. Research by Duong and Duong indicates that third-year students at a private educational institution in Vietnam apply creative skills moderately.[22] This suggests that while students can utilize creative talents in their learning processes, the frequency and extent of their application remain limited. This finding highlights that, among 21st-century learning skills, creativity is the least frequently utilized compared to communication, collaboration, and critical thinking, indicating that students have not fully realized their creative potential in academic settings.

Hard skills, while important, may receive less emphasis in the literature or search results, as they are often technical and can be acquired through specialized courses or practical work experience. Notably, despite the rapid changes driven by I4.0 in the workplace, skills such as adaptive thinking, virtual collaboration, and cognitive flexibility may not be extensively discussed. This could be attributed to the early stage of digital transformation in Vietnam, particularly in the traditional manufacturing and service sectors. For instance, virtual collaboration skills are critical in specific contexts. According to Masoni et al.,[23] augmented reality (AR), recognized as an emerging technology, is particularly valuable for improving maintenance services. AR facilitates remote equipment maintenance by connecting experts in control rooms with unskilled workers at the task site. In such scenarios, virtual collaboration skills become essential. However, the limited attention to these skills may indicate their lack of relevance in the Vietnamese context, warranting further investigation.

A one-sample t-test was conducted using the ttest_1samp function from scipy. Stats library, with the code structured as follows: t_statistic, p_value = stats.ttest_1samp (all_counts, popmean=0), where all_counts represents an array containing the keyword frequency values, and popmean=0 denotes the hypothesized population mean being tested. The code adheres to the formula for calculating the t-statistic value: $t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$

Where:

Sample mean; μ: Hypothesized population mean for comparison; *s*: Standard deviation; n: Sample size.

After calculating the t-statistic, the p-value is determined by finding the probability of the t-value in the t-distribution with n-1 degrees of freedom (df), where n is the sample size. The study reveals differences and similarities between the English and Vietnamese sources

based on the t-test results and statistical metrics (Table 1).

Critical thinking, communication, and creativity were the three most essential skills in English and Vietnamese contexts. All three skills exhibited high t-values, indicating significant differences in the frequency of related keyword occurrences. The very low p-value (0.0001) confirms these differences are statistically significant. However, when examining the standard deviation, communication displayed moderate variability (2.229 in English and 1.7829 in Vietnamese), suggesting relatively consistent data for this skill. In contrast, creativity showed a higher standard deviation, particularly in Vietnamese sources (2.5153), reflecting substantial variation in how this skill is addressed across sources. This may indicate that creativity is evaluated from diverse perspectives and contexts. Despite some variability, the results consistently underscore the critical role and uniform emphasis on these three skills across both languages.

Skills with lower frequency but notable statistical significance include qualitative skills ($t = 2.09$, $p = 0.0384$) and quantitative skills ($t = 2.71$, $p = 0.0074$) in English sources, and virtual collaboration ($t = 2.53$, $p = 0.012$) in Vietnamese sources. These findings highlight the importance of these skills in information analysis, complex data processing, and flexible work arrangements, despite their less frequent mention.

Table 1: t-test results table (English)

Skills	Std Dev	t value	p value
Communication	2.229	4.88	0.0001
Critical thinking	1.086	4.14	0.0001
Complex problem-solving	0.635	1.12	0.2656
Creativity	1.199	4.14	0.0001
Qualitative skill	1.623	2.09	0.0384
Quantitative skill	0.784	2.71	0.0074
Data interpretation	0.176	1.35	0.1805
Data visualization	0.192	1.64	0.1026
Cognitive flexibility	0.079	1.00	0.3188
Adaptive thinking ability	0.000	n/a	n/a
Virtual collaboration	0.000	n/a	n/a

Table 2: t-test results table (Vietnamese)

Skills	Std Dev	t value	p value
Communication	1,7829	4,98	0,0001
Critical thinking	0,6161	3,79	0,0002
Complex problem-solving	0,1404	2,02	0,0452
Creativity	2,5153	4,58	0,0002
Qualitative skill	1,6453	1,87	0,1009
Quantitative skill	0,1250	1,64	0,1041
Data interpretation	0,0000	n/a	n/a
Data visualization	0,0000	n/a	n/a
Cognitive flexibility	0,1577	1,34	0,1803
Adaptive thinking ability	0,0000	n/a	n/a
Virtual collaboration	0,2790	2,53	0,0120

Taken together, these findings not only identify specific skill sets in measurable terms but also quantify the issue, thereby extending previous research, as in earlier research, suggesting a general conclusion that students should strengthen professional competencies,[3] or develop adaptability.[4]

4. CONCLUSION AND IMPLICATIONS

The findings from this study have revealed unexpected and profound insights into the essential skills required for students in the context of I4.0. Through the process of data mining from websites, the results indicate that soft skills appeared with significantly higher frequency compared to technology-related hard skills. This suggests a critical shift in the perception of modern labor market requirements. While quantitative analysis, data visualization, and complex problem-solving remain essential, soft skills like communication, critical thinking, and creativity are increasingly indispensable for students to succeed and adapt to the rapidly evolving work environment. Students must not only master new technologies but also demonstrate proficiency in communication, critical thinking, creativity, and problem-solving. These findings underscore the importance of balancing the development of hard and soft skills in higher education, preparing students to confront challenges and seize opportunities in the new technological era.

Based on the research outcomes, several recommendations are proposed for policymakers, educational leaders, and business executives to ensure students are equipped with the necessary skills to meet the demands of the modern labor market. Among these, three urgent priorities should be highlighted for Vietnamese higher education:

- Curriculum orientation: The research findings indicate that soft skills such as communication, critical thinking, and creativity are becoming increasingly important. Universities and training institutions should strongly integrate these skills into their curricula, rather than focusing solely on domain-specific knowledge and technical skills. This integration can be achieved through dedicated soft skills courses, active learning methodologies, and group-based activities.

- Emphasizing internship programs and industry collaboration: Educational administrators should establish strong business partnerships to allow students to intern in real-world environments. Such experiences enable students to develop and refine essential communication, problem-solving, and teamwork skills. These practical

experiences are crucial in enhancing students' readiness for entering the labor market.

- Investing in faculty and innovative teaching methods: Faculty members should be trained and encouraged to adopt modern, student-centered teaching approaches that promote the development of communication and critical thinking skills through group discussions, debates, and case-based learning. Regular training sessions on integrating technology in teaching should also be supported to enhance instructional effectiveness.

- Fostering a creative learning and working environment: Educational institutions should cultivate an environment that encourages creativity by providing open and flexible learning spaces, supporting students' participation in innovation competitions, and promoting the development of real-world projects. Furthermore, school entrepreneurship and innovation programs should be actively developed to unlock students' creative potential.

Other complementary recommendations include promoting interdisciplinary learning, fostering a creative learning and working environment, accelerating digital transformation in education, expanding data literacy and analytical skills, and encouraging employers to revise recruitment and workforce development standards.

The limitation of this study lies in its reliance on factors extracted from a single prior study, which constrains the theoretical breadth and may omit context-specific determinants. By overlooking certain neglected areas, the study may fall short in fully identifying loopholes in the education and training system. In addition, interactive relations could be present between various skills. For example, critical and creative thinking can be improved by developing communication skills that enable workers to share ideas more freely. Similarly, complex problem-solving and quantitative skills may complement each other and allow workers to handle complicated situations through efficient data analysis techniques. Also, mental flexibility and adaptive thinking can enhance remote work performance since these attributes enable an individual to respond immediately to changes and challenges in unconventional work. By combining those skills, a synergistic effect may be achieved, and the job performance may improve, especially considering the digital transformation and the development of I4.0.

Based on the acknowledged limitations, future research could address these limitations by drawing on a broader range of prior studies or incorporating expert input to enrich the theoretical framework and capture context-specific determinants. Ongoing and future work could explore the effects of factors that have not yet been paid attention to in Vietnam, especially emerging skills, such as remote work and adaptive thinking. These competencies are increasingly vital in digital transformation and further development of the I4.0, but have not been pursued adequately enough in Vietnamese practices.

The next step of the research must be to assess the interrelatedness of these skills with the help of different analysis methods, e.g., multi-criteria decision-making (MCDM) methods. These methods can assist in discovering causal links and the level of interaction between skills on a more detailed level and reveal how such competencies impact each other, leading to the complexity of the development of human capital in the age of I4.0. In addition to bringing empirical evidence, these methods would enhance theoretical and practical knowledge based on skills development within the contemporary working environment.

Acknowledgments

We sincerely thank the reviewers for their invaluable comments, which were instrumental in strengthening this paper.

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