ONLINE JOURNAL FOR TVET PRACTITIONERS
e-ISSN: 2289-7410

OJ-TP

Vol. 9 No. 1 (2024) 73-83
https://publisher.uthm.edu.my/ojs/index.php/oj-tp

Assessing the Skillset Impacting the Readiness of HVAC Bachelor's Final Year Students for Industrial Revolution 4.0 (IR 4.0)

Razali, N.[1]*, Moriom, M. A.[1], Baharudin, N.[1], Masran, S. H.[1], Md Nor, M. H.[1], Zahmani, Q. F.[2]

[1] *Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, MALAYSIA*
[2] *Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, MALAYSIA*

*Corresponding Author: nizamuddin@uthm.edu.my
DOI: https://doi.org/10.30880/ojtp.2024.09.01.007

Article Info

Received: 26 March 2024
Accepted: 28 March 2024
Available online: 31 March 2024

Keywords

IR 4.0 readiness, non-technical skills, technical competency in HVAC

Abstract

The Industrial Revolution 4.0 (IR 4.0) is a significant period of industrial progress marked by advanced technologies like the Internet of Things (IoT) and Cyber-Physical Systems (CPS). The current change presents significant challenges and opportunities for various sectors, including the Heating, Ventilation, and Air Conditioning (HVAC) industry. Addressing the readiness of HVAC students for IR 4.0, this study investigates the gap in skills and competencies required in this new era. This study primarily assesses the readiness of final-year bachelor's degree students in HVAC, focusing on balancing technical and non-technical skills. Employing a qualitative descriptive research design, the study involved 100 final-year HVAC students from Universiti Tun Hussein Onn Malaysia (UTHM) and Universiti Teknikal Malaysia Melaka (UTeM). A structured questionnaire, developed based on a thorough literature review and validated through expert reviews and a pilot study, was used to collect data. The questionnaire assessed students' self-evaluation of their readiness, understanding of technical skills, and developing non-technical skills relevant to IR 4.0. The analysis revealed that students possess a high level of perceived readiness for IR 4.0, with non-technical skills emerging as significant contributors to their readiness. These skills accounted for 44% of the variance in students' readiness. The findings underscore the importance of integrating non-technical skills into the HVAC curriculum, highlighting their role in equipping students to navigate the evolving technological landscape of IR 4.0. In conclusion, the study provides comprehensive insights into the skillsets necessary for HVAC students to thrive in the IR 4.0 era. It emphasises the need for educational institutions to adapt their curricula and pedagogical strategies to include a balanced focus on technical and non-technical skills, thereby enhancing student employability and readiness for the challenges of the modern industrial world.

1. Introduction

The Fourth Industrial Revolution (IR 4.0) was a transformative era characterised by adopting advanced manufacturing technologies, such as automation and data exchange, which significantly changed machinery functioning. This paradigm shift enables machines to adjust and coordinate tasks independently, customising their capabilities to fulfil human requirements efficiently (Schwab, 2017). An essential aspect of this change involves incorporating various systems, including Industry 4.0, Advanced Management Programs, Cyber-Physical Systems (CPS), and the Internet of Things (IoT). These systems collectively contribute to what is commonly referred to as the Industrial Internet (Adegbite & Adeosun, 2021; Nagy et al., 2018; Xu et al., 2018). The combined operation of these technologies enables a smooth and intelligent manufacturing process that ensures improved productivity and cost-efficiency.

The period of the Fourth Industrial Revolution (IR 4.0) brings forth both challenges and opportunities, particularly in the field of technical education. The Internet and multimedia materials have greatly expanded students' perspectives, allowing them to acquire vital knowledge and resources essential for navigating the intricate details of the complex industrial environment (Kagermann et al., 2013). This is especially crucial for students in their last year of the HVAC (Heating, Ventilation, and Air Conditioning) bachelor's program as they are on the verge of joining the workforce. The dynamic character of the Fourth Industrial Revolution (IR 4.0) requires a workforce with technical proficiency, the capacity to adjust, and diverse soft skills (Benešová & Tupa, 2017).

Recognising the critical role of human capital in driving the success of IR 4.0 initiatives, this research explores the essential skill set that impacts the readiness of HVAC students for the industrial challenges ahead. Analyzing technical and non-technical skills offers valuable insights into students' self-perceived readiness for the IR 4.0 era (Abdullah et al., 2020; Al-Maskari et al., 2022). By conducting this research, the paper aims to meaningfully contribute to the critical ongoing discussion around synchronising what our educational systems teach with the shifting needs of the industry to best prepare the next cohort of engineers and technologies with the skills requisite to flourish within the quick transforming industrial environment.

Within the Fourth Industrial Revolution (IR 4.0) context, students studying HVAC (Heating, Ventilation, and Air Conditioning) represent a significant group. Future engineers in a field crucial for comfort and energy efficiency need to be prepared to adapt to and come up with new ideas within the IR 4.0 framework (Kattouw, 2016). The integration of smart technology, environmentally friendly energy solutions, and advanced automation systems is set to bring about a significant revolution in the HVAC business soon. These developments can completely change how building management, energy consumption, and indoor air quality are carried out. They are strongly aligned with the overall objectives of IR 4.0 (Jones & Cook, 2019).

Therefore, the curriculum for HVAC students must evolve to encompass not only the traditional principles of thermodynamics and fluid mechanics but also the nuanced skills required for smart building design, IoT integration, and energy management (Tanasiev et al., 2022a). This multidisciplinary approach prepares students to tackle real-world challenges, from optimising energy use in skyscrapers to ensuring sustainable practices in residential buildings. The imperative for HVAC students is to emerge as leaders in the transition towards more intelligent, efficient, and sustainable building environments.

This research examines the readiness of HVAC students for the upcoming industrial revolution. It is essential to comprehend the changing environment of the HVAC sector and how it relates to the principles of IR 4.0. This study aims to evaluate the skillsets of these students to provide valuable insights into how to best prepare them for the future of smart buildings and sustainable design. It will also examine the alignment of HVAC education with the demands of the Fourth Industrial Revolution.

1.1 Problem Statement

The advent of the Industrial Revolution 4.0 (IR 4.0) has introduced remarkable technological developments and digital transformations that have significantly altered the landscape of numerous industries, including HVAC (heating, ventilation, and air conditioning). Integrating digital technologies such as the Internet of Things (IoT), big data, and artificial intelligence into traditional industries, known as IR 4.0, is causing a dramatic transition in the skill set required for the HVAC workforce (Schwab, 2017). It is crucial for HVAC students, particularly those in their last year, to be well-prepared to adapt to this new way of doing things.

A Significant challenge in this shift is the noticeable need for alignment between the current educational outcomes and the changing requirements of the HVAC industry. The gap refers to a lack of basic knowledge and advanced technical skills among recent graduates, which makes it difficult for them to smoothly adapt to a work environment pushed by the fourth industrial revolution (Chen, 2003; Culp et al., 1990; Tanasiev et al., 2022b, 2022a). Furthermore, the fast-paced advancement of technology requires a highly skilled staff in both established and emerging HVAC technologies. This workforce must also demonstrate the capacity to adapt and a dedication to continuous learning throughout their careers.

Online Journal for TVET Practitioners Vol. 9 No. 1 (2024) p. 73-83

In order to address this problem, educational systems need to adopt a culture that emphasizes adaptability to digital technology and ongoing learning. The study conducted by Horn and Reynolds (2018) demonstrated the efficacy of incorporating an Information and Digital Literacy (IDL) framework into staff development programs to improve digital readiness. The study primarily examined a library environment, but the fundamental ideas for developing digital agility equally apply to HVAC education. This highlights the importance of adopting an interdisciplinary approach incorporating digital literacy, problem-solving, and critical thinking abilities (Horn & Reynolds, 2018).

Furthermore, understanding the professional development needs and priorities of the workforce, as explored by Caparotta, (2012) in the context of early childhood providers, can provide insights into how to approach the skill gaps in HVAC education (Caparotta, 2012). By identifying themes related to preparation for teaching and the adequacy of professional development opportunities, educators can tailor their programs to better equip students with the necessary technical and non-technical skills, such as problem-solving, critical thinking, and digital literacy, essential for success in the IR 4.0 era.

In conclusion, there is an urgent need for a comprehensive study on the skills that influence final-year students' readiness for bachelor's degrees in Refrigeration and Air Conditioning Systems (HVAC) for the Industrial Revolution 4.0. Such research will benefit the students by enhancing their employability and readiness and contribute to the broader goal of creating a workforce capable of driving and sustaining the advancements of IR 4.0.

1.2 Research Objectives

This study aims to thoroughly assess and further enhance the readiness of final-year HVAC students for the Industrial Revolution 4.0 (IR 4.0). The research is driven by four main objectives: (a) To obtain the perspectives of final-year HVAC students on their readiness for IR 4.0. The goal is to understand their self-evaluation of readiness for the technological and methodological changes that come with this era. (b) To assess the students' understanding and proficiency in the technical skills required for IR 4.0. This will focus on their depth of knowledge and practical skills that directly relate to IR 4.0 technologies and practices. (c) To examine the awareness and development of non-technical skills among these students, concentrating on soft skills essential for success in the evolving IR 4.0 landscape. (d) Lastly, to identify and categorise the critical skills that influence students' perceptions of readiness for IR 4.0. The goal is to create a comprehensive list of both technical and non-technical skills that students believe are crucial for navigating the challenges and opportunities of this new industrial era. Through these objectives, the study seeks not only to understand the current state of student readiness but also to identify and address gaps in education and training, thereby aligning HVAC programs more closely with the demands and opportunities of the Industrial Revolution 4.0.

2. Methodology

The methodology section of a research paper is a critical component that outlines the systematic approach employed to address the research questions and objectives. It delineates the comprehensive framework used to ensure the reliability and validity of the study's findings. This section encompasses several key elements: the study design, which provides a blueprint of the research's structure and strategy; the study population and sample, detailing the demographic and characteristics of the participants and the sampling methods used to select them; the study location, which contextualizes the research setting and its relevance to the study; and the study instruments, which describe the tools and techniques used to collect data.

Furthermore, the methodology addresses the validity and reliability of the instruments, ensuring that they accurately measure what they are intended to measure and can be consistently replicated. A pilot study may also be conducted to refine the research instruments and procedures, thereby enhancing the study's overall integrity. Finally, the data analysis methods are outlined, specifying the statistical or thematic techniques used to interpret the collected data and draw meaningful conclusions. Collectively, these components form the backbone of the research, providing a clear and replicable framework for conducting the study and ensuring that the results are robust, credible, and contribute effectively to the field of inquiry.

2.1 Research Design

This study adopts a qualitative descriptive research design, focusing on a detailed and accurate portrayal of the skillset impacting the readiness of HVAC Bachelor's Final Year Students for the Industrial Revolution 4.0 (IR 4.0). The primary method of data collection is a comprehensive questionnaire, designed to capture the nuanced perceptions and experiences of students regarding their preparedness for the evolving demands of the industry. The questionnaire will be developed based on a thorough literature review and existing validated instruments, ensuring that it comprehensively covers both technical and non-technical skills relevant to IR 4.0. To enhance the validity and reliability of the instrument, the questionnaire will undergo a rigorous validation process, including

expert reviews (Creswell & Creswell, 2018) and a pilot study with a subset of the target population (van Teijlingen & Hundley, 2002). This process will help refine the questions, ensuring they are clear, unbiased, and effectively capture the required information.

The study will be conducted among final year bachelor's degree students taking courses in the field of HVAC at Universiti Tun Hussein Onn Malaysia (UTHM, Johor) and Universiti Teknikal Malaysia Melaka (UTeM, Melaka). A purposive sampling technique will be employed to select participants who are most likely to provide rich, relevant, and diverse insights into the research questions (Palinkas et al., 2015). The sample size of 100 students, with 44 from UTHM and 56 from UTeM, has been determined using the Krejcie and Morgan Tables (Krejcie & Morgan, 1970) to ensure a representative sample that can accurately reflect the broader population's perceptions and experiences. Data from the completed questionnaires will be analyzed using the Statistical Package for the Social Sciences (SPSS) version 21.0. Descriptive statistics will provide a summary of the participants' demographics and responses, while inferential statistics, such as t-tests, will be used to examine the relationships between different variables and to compare subgroups within the sample (Field, 2013). This approach will be crucial in pinpointing and grouping the key skills that shape students' views on their readiness for IR 4.

The research design's strength lies in its focus on capturing the detailed, subjective experiences and perceptions of HVAC students regarding their readiness for IR 4.0. By employing a validated and comprehensive questionnaire, the study aims to provide valuable insights into the specific skillsets that are most critical for students as they prepare to enter a rapidly evolving industry. The findings are expected to inform curriculum development, pedagogical strategies, and policy decisions, ultimately contributing to the enhancement of HVAC education and the preparation of a workforce ready to meet the challenges of IR 4.0.

2.2 Research Instrument

The research instrument is a pivotal tool for gathering data from the sample population. In this research, a structured questionnaire serves as the primary instrument to collect data and gauge students' perceptions regarding the skillsets influencing the readiness of final year bachelor's students in the HVAC field for IR 4.0. Questionnaires are widely recognized as efficient research instruments due to their cost-effectiveness and ability to conserve time and energy in data collection (Sayed Ahmad & Mustaffa, 2010). This questionnaire was developed to align with the study's objectives and research questions. It is divided into sections, each designed to gather specific information to address research questions.

The questionnaire's structure incorporates multiple-choice questions in Section A and employs a Likert scale for Sections B, C, and D. The items within this questionnaire are adapted from prior studies, ensuring a robust and relevant framework for analysis. The distribution of questionnaire items and their sources is as shown in Table 1:

Table 1 *Distribution of questionnaire items and sources*

Section	Construct	Question No	Items	Sources
A	Demographic Data	1-3	A1-A3	Researcher
B	Perceptions of final year HVAC students on readiness to face IR 4.0	1-4	B1-B4	(Abd Rahman et al., 2019)
C	Perceptions of final year HVAC students on IR 4.0 technical skills.	1-10	C1-C10	(Jamil et al., 2021)
D	Perceptions of final year HVAC students on IR 4.0 non-technical skills.	1-10	D1-D10	(Kamaruzaman et al., 2019)

Prior to distribution, the questionnaire undergoes a rigorous validation process. It is initially reviewed by subject matter experts to ensure content validity and relevance. Subsequently, a pilot study is conducted with non-final year students enrolled in HVAC courses to test the instrument's reliability and comprehensiveness. Feedback from this preliminary phase leads to necessary revisions and enhancements, ensuring the questionnaire's effectiveness in capturing the nuanced perceptions and readiness of students for IR 4.0.

Recent studies have emphasized the importance of understanding students' characteristics, knowledge of 4IR technologies, and organizational dimensions in assessing their preparedness for the fourth industrial revolution. Al-Maskari et al. (2022) found that these factors significantly impact students' preparedness for the 4IR, with organizational dimensions having the highest impact (Al-Maskari et al., 2024). Additionally, Sahul Ahmid et al. (2023) highlighted the significant effects of innovative characteristics, work readiness, and vocational self-concept on the employability of vocational college students, which can be extrapolated to HVAC students preparing for IR 4.0 ((Sahul Ahmid et al., 2023)). These insights have been integrated into the design and focus of the questionnaire, ensuring a comprehensive assessment of the factors impacting student readiness for the evolving industrial landscape.

Online Journal for TVET Practitioners Vol. 9 No. 1 (2024) p. 73-83

3. Results and Discussion

In this study, descriptive statistics, specifically mean scores and standard deviations, were employed to evaluate the perceptions of HVAC final year students regarding their readiness for Industry 4.0 (IR 4.0). This evaluation encompassed three key areas: students' views on their overall readiness for IR 4.0, their technical skills, and their non-technical skills. Furthermore, inferential statistical analysis, utilizing a Regression Test, was conducted to identify which specific skills most significantly influence the students' preparedness for the challenges of IR 4.0.

3.1 Sample Profile

The current study involved a sample of 100 final-year students specializing in HVAC from two institutions: Universiti Tun Hussein Onn Malaysia (UTHM) in Johor and Universiti Teknikal Malaysia Melaka (UTeM) in Melaka. The primary objective of this section is to present the demographic background of the participants, including gender, the institution of study, and their current semester. The demographic data are summarized in Table 2.

Table 2 *Demographic background of the study sample*

Data Demographic	Frequency	Percentage (%)
Gender		
Male	67	67.0
Female	33	33.0
Total	100	100.0
Institutions		
UTHM	44	44.0
UTeM	56	56.0
Total	100	100.0
Semester		
Semester 6	31	31.0
Semester 7	22	22.0
Semester 8	46	46.0
Semester 9	1	1.0
Total	100	100.0

3.2 Perceptions of Final Year HVAC Students Regarding Readiness for Industrial Revolution 4.0

The study's findings reveal that the final year HVAC students exhibit a notably high perception of readiness to engage with the challenges of IR 4.0. The overall mean score indicates an excellent level of readiness (M = 4.39, SD = 0.459). This high level of perceived readiness is evident across various aspects, as detailed in Table 3.

Table 3 *Mean distribution of final year students' perceptions of HVAC on IR 4.0 readiness*

Items	Mean	Standard Deviation (SD)	Mean Score Level
B1. I am ready to adapt to the current changes of IR 4.0.	4.33	0.570	Very High
B2. I am willing to follow the training provided by the institute towards IR 4.0	4.57	0.517	Very High
B3. I am ready to learn new knowledge provided by institutions towards IR 4.0.	4.53	0.521	Very High
B4. I am ready to take the challenge of IR 4.0.	4.16	0.707	High
Overall Average	4.39	-	Very High

Notably, Item B2, "I am ready to follow the training provided by the institute towards IR 4.0," garnered the highest mean score (M = 4.57, SD = 0.517), suggesting a strong inclination among students to engage in institute-provided training as a preparation for IR 4.0. This enthusiasm could be attributed to their imminent transition from academia to the professional world, highlighting a readiness to embrace relevant training opportunities. This finding aligns with the research by Mittal et al. (2022), who emphasized the importance of institutional training in preparing students for the technological demands of the modern workforce. Conversely, Item B4, "I am ready to take the challenge of IR 4.0," received the lowest mean score (M = 4.16, SD = 0.707). This relatively lower score may reflect a hesitancy among students to confront the more complex technological challenges associated with IR

4.0. Despite this, the mean score for this item still falls within the 'High' category, indicating a generally positive outlook among students towards facing the era of IR 4.0. This observation is consistent with the findings of Warmansyah et al. (2022), who noted similar apprehensions among students in adapting to complex technological environments.

3.3 Perceptions of Final Year HVAC Students on IR 4.0 Technical Skills

The study's findings reveal that final year HVAC students possess a high understanding of IR 4.0 technical skills, as indicated by the overall mean score (M = 3.92, SD = 0.483). This score suggests that most of the students are well-versed in and capable of applying these technical skills in the HVAC field. The detailed perceptions of the students are shown in Table 4.

Table 4 *Mean distribution of final year students' perceptions of HVAC on IR 4.0 technical skills*

Items	Mean	Standard Deviation	Level
C1. I know the commercial air conditioning maintenance monitoring process can be done online using a mobile device.	4.05	0.702	High
C2. I can do commercial air conditioning maintenance monitoring online using a mobile device.	3.85	0.880	High
C3. I was able to identify the cause of the problem in the HVAC system based on the error code displayed.	3.94	0.763	High
C4. I can do troubleshooting in HVAC systems.	4.00	0.804	High
C5. I have skills in using software to design HVAC systems (AutoCAD, REVIT & HAP).	4.04	0.618	High
C6. I have skills in using 3D printing using computer aided design (CAD) to create three -dimensional objects related to HVAC systems.	3.77	0.750	High
C7. I have skills in using IoT related software (Arduino) to control HVAC systems.	3.12	1.104	Moderate
C8. I have skills in accessing spreadsheets to enter the required data in IR 4.0.	3.95	0.757	Moderate
C9. I can access internet applications or software needed for documentation or finding information.	4.21	0.608	Very High
C10. I am able to use information technology in displaying the data obtained	4.30	0.577	Very High
Overall Average	4.39	-	Very High

A notable finding is the highest mean score for Item C10, "I am able to use information technology in displaying the data obtained" (M = 4.30, SD = 0.577). This high score can be attributed to the prevalent use of information technology in the students' learning processes. The integration of ICT in technical and vocational education, as discussed in the systematic literature review by Hassan et al. (2021), emphasises the growing importance of digital skills in technical fields. Conversely, the lowest mean score was observed for Item C7, "I have skills in using IoT (Arduino) related software to control HVAC systems" (M = 3.12, SD = 1.104), suggesting a relative unfamiliarity among students with IoT-related software in HVAC systems. This finding aligns with the study by Sun (2023), which highlights the need for vocational colleges to cultivate technical and skilled talents in IoT, addressing the talent demand gap in the industry. These insights underscore the need for educational institutions to adapt their curricula to include more comprehensive training in emerging technologies like IoT. Integrating innovative teaching modes, such as the "flipped classroom," could be beneficial in enhancing technical skills relevant to IR 4.0, as suggested by the research on vocational education teaching modes (Yu et al., 2019).

3.4 Perceptions of Final Year HVAC Students on Non-Technical Skills for IR 4.0

The study's findings indicate a high level of proficiency among final-year HVAC students in IR 4.0 non-technical skills, as reflected by the overall mean score (M = 4.20, SD = 0.491). This suggests that students possess a robust understanding and application of these skills, which are essential for their future professional engagements. Table 5 presents the detailed findings.

Table 5 *Mean distribution of final year students' perceptions of HVAC on IR 4.0 non-technical skills*

Items	Mean	Standard Deviation (SD)	Mean Score Level
D1. I can lead colleagues while working in a team.	4.12	0.656	High
D2. I was able to actively participate in a team.	4.22	0.660	Very High
D3. I can come up with new ideas in a discussion.	4.18	0.642	High

Online Journal for TVET Practitioners Vol. 9 No. 1 (2024) p. 73-83

D4. I can use the best alternatives for problem solving.	4.26	0.562	Very High
D5. I can plan problem -solving strategies by thinking critically.	4.08	0.734	High
D6. I can solve problems by acting rationally.	4.32	0.601	Very High
D7. I show good work ethic while carrying out assignments.	4.46	0.521	Very High
D8. I can manage time effectively in handling tasks.	4.23	0.737	Very High
D9. I can communicate in a variety of situations.	4.18	0.687	High
D10. I can communicate in English very well.	3.96	0.764	High
Overall Average	4.20	-	High

Significantly, the highest mean score was for Item D7, "I show good work ethic while performing tasks" (M = 4.46, SD = 0.521), highlighting the students' strong commitment to work ethics in their assignments. This aligns with the findings of Verde et al. (2023), who emphasised the positive impact of non-technical skills training on professional efficiency and safety in healthcare. This context can be paralleled in technical fields like HVAC.

In contrast, Item D10, "I can communicate in English well," received the lowest mean score (M = 3.96, SD = 0.764). This score may be influenced by the predominance of English in academic settings, yet a lesser emphasis on its practical usage in daily interactions. Nonetheless, this item still rates highly, indicating a competent level of English communication skills among students. The importance of effective communication in technical fields is further supported by the study on paramedic placements by Spencer et al. (2023), highlighting the crucial role of non-technical skills in professional settings.

Moreover, the role of non-core disciplines, including non-technical skills, in the professional education of technical university students is underscored in research by Ivashchenko & Ogoltsova (2023). Their study emphasises the necessity of these skills in preparing students for new economic realities. Lastly, the study by Kopzhasarova et al. (2021) on improving foreign language skills among technical speciality students resonates with the findings of this study, particularly regarding the importance of language skills in a global professional environment.

3.5 Influence of Technical and Non-Technical Skills on HVAC Students' Readiness for IR 4.0

This study segment employed a regression test to examine the influence of technical and non-technical skills (independent variables) on students' readiness to face Industrial Revolution 4.0 (dependent variable). The null hypothesis posited that neither IR 4.0 technical nor non-technical skills significantly predict HVAC students' readiness for IR 4.0. Table 6 presents the regression analysis results.

Table 6 *Influence of independent variables on dependent variables*

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.528	0.334		4.573	0.000
	Technical skills	0.218	0.085	0.230	2.561	0.012
	Non-Technical skills	0.479	0.084	0.513	5.721	0.000

The analysis indicated that technical and non-technical skills are significant predictors of students' readiness for IR 4.0, leading to the rejection of the null hypothesis ($p = 0.000 < .05$). Together, these skills account for 44% of the variance in students' readiness. Notably, non-technical skills ($\beta = 0.513$) emerged as a more potent predictor than technical skills ($\beta = 0.230$).

In conclusion, the analysis underscores the significant impact of technical and non-technical skills on students' readiness for IR 4.0. However, it highlights that non-technical skills substantially influence final-year HVAC students' perceptions of readiness for the IR 4.0 era. This suggests that non-technical skills are crucial in bolstering students' confidence in facing the challenges of IR 4.0. The importance of non-technical aspects in readiness and training is supported by the study on Air Force trainees by Ellis et al. (2023), demonstrating how factors like sleep health significantly impact operational readiness.

Furthermore, the readiness of technical specialities students for blended learning, particularly in foreign language education, as explored by Kisel et al. (2021), provides valuable insights into the impact of educational interventions on student readiness. This study highlights the effectiveness of blended learning approaches in developing various skills, contributing to successfully mastering a course. This is relevant to understanding the influence of technical and non-technical skills on HVAC students' readiness for IR 4.0. The research underscores

the importance of innovative educational methods in preparing students for the challenges of the modern industrial landscape.

4. Conclusion and Suggestions

This study aimed to identify the particular competencies that enhance the readiness of final-year bachelor's degree students in HVAC for the Industrial Revolution 4.0 (IR 4.0). A significant finding is the pivotal role of non-technical skills in preparing students for the challenges of IR 4.0. Specifically, it was observed that these skills, as possessed by students at Universiti Tun Hussein Onn Malaysia (UTHM) and Universiti Teknikal Malaysia Melaka (UTeM), considerably contribute to their readiness for IR 4.0. This research has important implications for several stakeholders in the education sector, such as university faculties, students, and lecturers. It can serve as a significant resource for developing curriculum and pedagogical strategies. The study effectively achieved its aims and answered the research questions thoroughly.

The insights gained from this study will catalyse future research and contribute to ongoing efforts in optimising educational practices for the IR 4.0 era. The results emphasise the significance of integrating non-technical skills into the HVAC curriculum, underlining their importance in preparing students to handle the changing technology environment. The study conducted by Sambhwani et al. (2021) emphasizes the importance of cultivating non-technical skills and personal growth to adjust to new educational and professional settings effectively. Furthermore, the incorporation of foreign language instruction, as examined by Leushina & Leushin (2022), highlights the significance of communication abilities in advancing one's career, which is relevant to HVAC education in the era of IR 4.0.

There is a need for further research in investigating the effectiveness and influence of incorporating innovative instructional methods, such as blended learning and flipped classrooms, into HVAC courses. This study emphasises the need for technical and non-technical skills to prepare HVAC students for the challenges of IR 4.0. It highlights that students need to be well-prepared and that non-technical skills are significant in this readiness. Further research could explore the efficacy of these teaching methods in improving the acquisition of Industry 4.0-related skills among HVAC students. This could include evaluating student engagement, learning outcomes, and readiness for IR 4.0 challenges in environments that adopt innovative teaching methods compared to traditional instructional approaches. Such research would provide valuable insights into curriculum development and pedagogical strategies, aligning educational practices with the evolving demands of the HVAC industry in the era of IR 4.0.

Acknowledgement

This research was made possible thanks to the support and facilities provided by the Faculty of Technical and Vocational Education at Universiti Tun Hussein Onn Malaysia. Their assistance in providing the necessary resources and the opportunity to conduct this study is greatly appreciated. Additionally, gratitude is extended to all individuals who contributed to the research process.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the paper's publication.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design:*** *Moriom, Marlini Alex[1], Razali, Nizamuddin[1];* ***data collection:*** *Moriom, Marlini Alex[1], Razali, Nizamuddin[1], Zahmani, Qamar Fairuz[2];* ***analysis and interpretation of results:*** *Razali, Nizamuddin[1*], Moriom, Marlini Alex[1], Baharudin, Nurhayati[1], Masran, Saiful Hadi[1]* ***draft manuscript preparation:*** *Moriom, Marlini Alex[1], Razali, Nizamuddin[1], Md Nor, Mohd Hairwan[1]. All authors reviewed the results and approved the final version of the manuscript.*

References

Abd Rahman, A., Pannirchelvi, S., Ng Kim, S., Hairul Rizad, M. S., & Siti Sarah, O. (2019). Factors Influence the Students' Readiness on Industrial Revolution 4.0. International Journal of Recent Technology and Engineering (IJRTE), 8(2S).

Abdullah, Q. A., Humaidi, N., & Shahrom, M. (2020). Industry revolution 4.0: the readiness of graduates of higher education institutions for fulfilling job demands. Revista Română de Informatică Şi Automatică, 30(2), 15–26. https://doi.org/10.33436/v30i2y202002

Adegbite, W. M., & Adeosun, O. T. (2021). Fourth Industrial Revolution Skillsets and Employability Readiness for Future Job. Global Journal of Social Sciences Studies, 7(1), 35–49. https://doi.org/10.20448/807.7.1.35.49

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

Al-Maskari, A., Al Riyami, T., & Ghnimi, S. (2024). Factors affecting students' preparedness for the fourth industrial revolution in higher education institutions. Journal of Applied Research in Higher Education, 16(1), 246–264. https://doi.org/10.1108/JARHE-05-2022-0169

Benešová, A., & Tupa, J. (2017). Requirements for Education and Qualification of People in Industry 4.0. Procedia Manufacturing, 11, 2195–2202. https://doi.org/10.1016/j.promfg.2017.07.366

Caparotta, C. (2012). Professional Development Needs of Early Childhood Providers: A Focus Group Study.

Chen, C. C. (2003). The Next Generation Of Hvac Engineers And Training In Mechanical Engineering. Annual Conference Proceedings, 8.1155.1-8.1155.5. https://doi.org/10.18260/1-2--12670

Creswell, J. W., & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications. https://books.google.com.my/books?id=s4ViswEACAAJ

Culp, C. H., Haberl, J. S., Norford, L. K., & Hall, J. D. (1990). The impact of AI technology within the HVAC industry. Ashrae Journal, 32, 12–22. https://api.semanticscholar.org/CorpusID:107422274

Ellis, J., Burns, R. E., Mallawaarachchi, I., Qun, X. W., Cassidy, D., Aycock, C., Krunnfusz, A., Jones, J., Klesges, R., & Talcott, W. (2023). Evaluation of a Single-Session Sleep Intervention for Air Force Trainees. SLEEP, 46(Supplement_1), A403–A403. https://doi.org/10.1093/sleep/zsad077.0913

Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics: And Sex and Drugs and Rock "N" Roll, 4th Edition. Sage.

Hassan, R. H., Hassan, M. T., Naseer, S., Khan, Z., & Jeon, M. (2021). ICT Enabled TVET Education: A Systematic Literature Review. IEEE Access, 9, 81624–81650. https://doi.org/10.1109/ACCESS.2021.3085910

Horn, A., & Reynolds, E. (2018). Developing a digital culture and embedding digital agility within a library workforce. Proceedings of the IATUL Conferences.

Ivashchenko, Y. S., & Ogoltsova, E. G. (2023). The role of non-core disciplines in the professional education of students of technical universities. Perspectives of Science and Education, 61(1), 90–107. https://doi.org/10.32744/pse.2023.1.6

Jamil, M., Sepikun, M., & Muhammad, M. (2021). Kesediaan Pelajar Diploma Kejuruteraan Elektronik (Komputer) Mengaplikasikan Kemahiran Teknikal Bagi Menghadapi Cabaran Kerjaya dalam Internet of Things (IoT) : Readiness of Electronic Engineering (Computer) Diploma Students in Applying Technical Skills to Face Career Challenges in Internet of Things (IoT). Online Journal for TVET Practitioners, 6(1), 45–58.

Jones, P., & Cook, M. (2019). Smart buildings: Advanced materials and nanotechnology to improve energy-efficiency and environmental performance. Journal of Nanotechnology in Engineering and Medicine.

Kagermann, H., Wahlster, W., & Helbig, J. (2013). Securing the Future of German Manufacturing Industry: Recommendations for Implementing the Strategic Initiative Industrie 4.0. Final Report of the Industrie 4.0 Working Group.

Kamaruzaman, M. F., Hamid, R., Mutalib, A. A., & Rasul, M. S. (2019). Comparison of Engineering Skills with IR 4.0 Skills. International Journal of Online and Biomedical Engineering (IJOE), 15(10), 15. https://doi.org/10.3991/ijoe.v15i10.10879

Kattouw, J. W. (2016). Comfort as a Service with SMART HVAC : a constructive technology assessment of the developments in the HVAC industry. https://api.semanticscholar.org/CorpusID:114005584

Kisel, O. V., Gasanenko, E. A., Dubskikh, A. I., & Butova, A. V. (2021). READINESS OF TECHNICAL SPECIALTIES STUDENTS FOR BLENDED LEARNING A FOREIGN LANGUAGE. AZIMUTH OF SCIENTIFIC RESEARCH: PEDAGOGY AND PSYCHOLOGY, 10(34). https://doi.org/10.26140/anip-2021-1001-0038

Kopzhasarova, U., Beisenbaeva, B., & Alken, S. (2021). Improvement of technical specialty students' foreign language professional skills. Bulletin of Karaganda University. Pedagogy Series, 102(2), 157–163. https://doi.org/10.31489/2021Ped2/157-163

Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. Educational and Psychological Measurement, 30(3), 607–610. https://doi.org/10.1177/001316447003000308

Leushina, I. V., & Leushin, I. O. (2022). Foreign language and practical training of students and graduate students of a non-language university. Bulletin of Nizhnevartovsk State University, 59(3), 66–75. https://doi.org/10.36906/2311-4444/22-3/06

Mittal, S., Mahapatra, M., & Ansari, S. (2022). Art therapy and technology in secondary education. International Journal of Health Sciences, 11117–11125. https://doi.org/10.53730/ijhs.v6nS6.13045

Nagy, J., Oláh, J., Erdei, E., Máté, D., & Popp, J. (2018). The Role and Impact of Industry 4.0 and the Internet of Things on the Business Strategy of the Value Chain—The Case of Hungary. Sustainability, 10(10), 3491. https://doi.org/10.3390/su10103491

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. Administration and Policy in Mental Health and Mental Health Services Research, 42(5), 533–544. https://doi.org/10.1007/s10488-013-0528-y

Sahul Ahmid, S., Chun, T. C., & Abdullah, M. N. L. Y. (2023). The Influence of Innovative Characteristics, Work Readiness, and Vocational Self-Concept on Employability of Vocational College Students. International Journal for Research in Vocational Education and Training, 10(3), 288–317. https://doi.org/10.13152/IJRVET.10.3.1

Sambhwani, S., Al-Shahwani, A., & Sheikh, N. (2021). Maintaining Surgical Education and Team Morale During A Pandemic – Can A Virtual Educational Platform Deliver Effective Engagement and Personal Development of Non-Technical Skills? British Journal of Surgery, 108(Supplement_2). https://doi.org/10.1093/bjs/znab134.167

Sayed Ahmad, S. M., & Mustaffa, F. (2010). Kemahiran Berkomunikasi Secara Berkesan Dalam Kalangan Pelajar Sarjana Muda Sains Serta Pendidikan (Pengajian Islam). Universiti Teknologi Malaysia.

Schwab, K. (2017). The Fourth Industrial Revolution. Crown Publishing Group.

Spencer, J., Hamilton, C., Rimmer, J., & Clarke, C. (2023). A Paramedic placements: Let's not forget the non-technical skills. International Journal of Healthcare Simulation. https://doi.org/10.54531/HHWZ4964

Sun, J. (2023). Practice and Exploration of the Construction of New Engineering Skills Studios under the "Three navigation and Five Integration" Model from the Perspective of Industrial Demands. Journal of Computing and Electronic Information Management, 10(3), 147–149. https://doi.org/10.54097/jceim.v10i3.8761

Tanasiev, V., Pluteanu, Ștefăniță, Necula, H., & Pătrașcu, R. (2022a). Enhancing Monitoring and Control of an HVAC System through IoT. Energies, 15(3), 924. https://doi.org/10.3390/en15030924

Tanasiev, V., Pluteanu, Ștefăniță, Necula, H., & Pătrașcu, R. (2022b). Enhancing Monitoring and Control of an HVAC System through IoT. Energies, 15(3), 924. https://doi.org/10.3390/en15030924

van Teijlingen, E., & Hundley, V. (2002). The importance of pilot studies. Nursing Standard, 16(40), 33–36. https://doi.org/10.7748/ns2002.06.16.40.33.c3214

Verde, V., Bardacci, Y., Ballerini, L., Baldassini Rodriguez, S., Balestri, C., Iovino, P., Belli, S., & Bambi, S. (2023). Learning teamworking and non-technical skills: a pilot study of a postgraduate course at the University of Florence. Infermieristica Journal, 2(2), 89–100. https://doi.org/10.36253/if-2080

Online Journal for TVET Practitioners Vol. 9 No. 1 (2024) p. 73-83

Warmansyah, J., Komalasari, E., Febriani, E., Gusmiati, & Amalina. (2022). Factors Affecting Teacher Readiness for Online Learning (TROL) in Early Childhood Education: TISE and TPACK. JPUD - Jurnal Pendidikan Usia Dini, 16(1), 32–51. https://doi.org/10.21009/JPUD.161.03

Xu, H., Yu, W., Griffith, D., & Golmie, N. (2018). A Survey on Industrial Internet of Things: A Cyber-Physical Systems Perspective. IEEE Access, 6, 78238–78259. https://doi.org/10.1109/ACCESS.2018.2884906

Yu, H., An, J., & Dou, T. (2019). Design and Application Research of Flipped Classroom Teaching Model in Applied Undergraduate Colleges -Taking Management Courses as an Example. Proceedings of the 2019 International Conference on Management, Education Technology and Economics (ICMETE 2019). https://doi.org/10.2991/icmete-19.2019.17