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RESEARCH ARTICLE

Competency of TVET Lecturers in Digital and Automation at Public Higher Education Institutions in IR 4.0

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ABSTRACT

Digital and Automation Competency among Technical and Vocational Education and Training (TVET) lecturers are crucial in facing the Fourth Industrial Revolution (IR 4.0). Digital technology and automation have the potential to enhance the quality of education in the country. This study aims to identify the constructs and sub-constructs needed by TVET lecturers to ensure that teaching and learning sessions are more engaging and on par with those in developed countries. The study was conducted quantitatively, involving 107 lecturers from public universities. The results, analyzed using the Statistical Package for Social Sciences (SPSS), provided data such as mean statistics, frequency, standard deviation, and ANOVA. The level of digital and automation competency among TVET lecturers was found to be high (mean = 3.80). Therefore, the digital and automation competency of TVET lecturers at public universities represents a transformation in the education sector, particularly in the TVET field, contributing to the country's development towards IR 4.0.

Contribution/Originality: The paper's primary contribution is finding that degree of digital competency and automation skills among TVET lecturers in Malaysian higher education institutions for effective teaching and learning in the digital era. These findings provide important insights for the development of targeted professional development to strengthen lecturers' technological proficiency and preparedness to meet future educational demands.

1. Introduction

The Fourth Industrial Revolution (IR 4.0) is a term frequently heard today, representing digital technology characterised by the integration of digital, biological, and physical worlds. IR 4.0 is rapidly transforming all economies, including Malaysia's education

system, which has experienced significant changes since the introduction of IR 4.0. Furthermore, Malaysia's education system requires improvements to produce human capital as the main pillar, as highlighted in the National Philosophy of Malaysian Education (NPME) (Muzzafar & Jamalullail, 2020). The Ministry of Education has taken proactive measures to ensure the education system remains competitive in the era of Industry 4.0 by introducing the Malaysia Education Blueprint 2015-2025 (Higher Education) (MEB 2015-2025 (HE)). The fourth thrust in MEB 2015-2025 (HE) focuses on producing quality Technical and Vocational Education and Training (TVET) graduates. Improving the quality of educators is an initiative by the MOE to ensure the achievement of this fourth thrust (Ministry of Education, 2015). TVET lecturers are educators within TVET institutions who must possess high competency to produce skilled workers. Additionally, lecturers' competencies need to be continually honed and improved to serve as role models for graduates who will face the advent of IR 4.0. This aligns with the study by Kowang et al. (2020), which found that lecturers in Public Higher Education Institutions (PHEIs) need to enhance their IR 4.0 competencies based on five recommended constructs.

In the MEB 2015-2025, the ministry states that Malaysia faces a shortage of medium and high-skilled workforce (Ministry of Education, 2015). This statement is consistent with research conducted by Fateh et al. (2022), in which the Malaysian industry is facing a significant shortage of local skilled labor, which is its biggest challenge. Additionally, the percentage of skilled workforce in Malaysia was notably low in 2016, standing at only 28% compared to 100% in Finland and 80% in Germany (Department of Information Malaysia, 2017). This is due to Rüßmann et al. (2015), who introduced nine technologies under Industry 4.0 that transformed methods and implementations in the manufacturing sector. Moreover, Klaus Schwab, Executive Chairman of the World Economic Forum, introduced the concept of IR 4.0, which has the potential to create a more inclusive economy (Effoduh, 2016). As a result, developed countries generally have a greater abundance of skilled labour compared to Malaysia.

The Malaysian government, through the Ministry of International Trade and Industry, has embraced the advent of IR 4.0 by introducing the Industry4WRD: National Policy on Industry 4.0. This policy was launched on October 31, 2018, to drive digital transformation in the manufacturing and related services sectors in Malaysia (Ministry of International Trade and Industry, 2018). Additionally, Ministry of International Trade and Industry (2018) reported that Malaysia's labour productivity ranked 44th from 2009 to 2016. In response to these challenges, the Ministry of International Trade and Industry has implemented strategies aimed at improving current skill sets and nurturing prospective talent among young individuals. IR 4.0 will impact the TVET education system in Malaysia. Therefore, the Department of Polytechnic and Community College Education (JPPKK) has developed the TVET 4.0 Framework to ensure that TVET institutions can meet the demand for skilled labour. To maintain TVET institutions' contribution of 30% to the workforce, talents and skills within these institutions need continual enhancement to uphold the quality of TVET programs at a high level (Department of Polytechnic and Community College Education, 2018).

1.1. Research Objectives

Lecturers' competency in the digital era refers to the set of skills, knowledge, and attitudes educators must possess to teach students. The rapid integration of digital tools and resources in education forces lecturers to adapt and acquire various skills, especially in digital technology, to meet their students' needs and enhance educational quality.

Ratheeswari (2018) stated that the integration of Information and Communication Technology (ICT) can improve Teaching and Learning (T&L) strategies. Nevertheless, as highlighted by International Labour Organization (2020), a significant number of educators lack adequate digital knowledge and skills, thereby affecting the potential for digital transformation within the TVET sector, particularly in classroom T&L methodologies.

According to Mohd. Jamil et al. (2023), educators in the TVET field need a solid understanding of technology, especially in pedagogical approaches. Lecturers must equip themselves with knowledge of digital technology and automation and be prepared and capable of using it. Previous studies also indicate that TVET lecturers at Vocational Colleges (KV) have a moderate level of acceptance towards e-learning. Research by Rozali et al. (2021) found that the perception of TVET lecturers at Polytechnics towards online learning is moderate. These findings are attributed to the limited facilities available for conducting T&L using digital technology. This can be evidenced by the study conducted by Damit and Omar (2019), which stated that infrastructure factors, such as inadequate internet access in Higher Education Institutions (HEIs), indirectly hinder lecturers' efforts to use technology in implementing e-learning in T&L.

2. Literature Review

The Fourth Industrial Revolution, or Industry 4.0 (IR 4.0), is characterised by rapid advancements in technology, industry, and societal patterns and processes in the 21st century, driven by increased connectivity and smart automation. IR 4.0 is expected to bring numerous positive changes, making national economies and industries more compact and efficient. A study by Salahudin and Rosman (2021) indicates that students have a high level of understanding and readiness for IR 4.0. This shows that the younger generation is highly aware of the changes that IR 4.0 will bring. Furthermore, IR 4.0 will feature a highly advanced environment, including interconnected computers, smart materials, and intelligent machines that communicate with each other, interact with their surroundings, and make decisions with minimal human involvement (Ghobakhloo, 2020).

In the context of higher education, IR 4.0 focuses on smart technologies, artificial intelligence, and robotics in teaching and learning. Therefore, PHEIs must be prepared and ensure that adequate facilities are available to create a smart campus. A study conducted by Alghamdi and Shetty (2016) found that the use of IoT in campuses has positive impacts, such as providing effective, efficient, and high-quality services to university or campus communities. Research by Muhamad et al. (2017) also indicated that smart classrooms are an application of the smart campus concept. A smart classroom provides various services accessible via mobile devices, such as the Learning Management System (LMS), which can meet the needs of recording data related to teaching and learning activities. These include course syllabus, class schedules, student attendance, group project assignments, and the preparation and execution of tasks.

Among the findings of previous studies related to IR 4.0 is the research by Wei Boon et al. (2021), which indicates that instructors at Sungai Petani Community College have a moderate level of readiness for online teaching and learning sessions. The skill levels of the instructors in their research were also moderate. Additionally, research by Hamzah et al. (2021) found that lecturers' knowledge of using IoT tools remains at a moderate level. This is due to the lecturers' lack of knowledge and skills in using these platforms. From another perspective, research by Amran and Yahya (2020) stated that the main constraint

faced by lecturers in using technology for educational purposes in their teaching is technical support. This is evidenced by studies showing that trainee teachers still have a moderate understanding of IR 4.0 due to limited internet access (Lai et al., 2020).

3. Research Methods

This study is using quantitative research design conducted through a survey method using a questionnaire. The survey was distributed by the researcher to TVET lecturers specialising in mechanical engineering at selected Public Higher Education Institutions (PHEIs). As described by Creswell (2012), quantitative research that combines descriptive and inferential studies aims to comprehensively explore a research topic. Therefore, it is suitable for the purpose of this study, which is to assess the level of competency among lecturers in digital technology and automation at PHEIs.

The researcher identified a study population of 153 TVET lecturers from 7 selected Public Higher Education Institutions (PHEIs): Universiti Malaysia Perlis (UniMAP), Universiti Malaysia Pahang (UMP), Universiti Pendidikan Sultan Idris (UPSI), Universiti Putra Malaysia (UPM), Universiti Teknikal Malaysia Melaka (UTeM), Universiti Tun Hussein Onn Malaysia (UTHM), and Universiti Teknologi Malaysia (UTM). These lecturers specialise in vocational education and mechanical engineering. According to Uakarn et al. (2021), the use of Krejcie and Morgan (1970)'s table is suitable for survey studies. Therefore, based on the Krejcie and Morgan (1970) table, a sample size of 107 respondents is required to ensure the success of this study.

This study will utilise a non-probability quota sampling technique to select TVET lecturers from seven chosen PHEIs. By using this approach, the researcher can intentionally choose participants who fit particular requirements, ensuring representation across significant variables like institutional type, subject matter expertise, and teaching experience. The use of quota sampling is ideal for this study because it allows for the inclusion of various points of view within the TVET teaching community while adhering to practical constraints related to size of sample and accessibility. The researcher conducted quota sampling, segregating all TVET lecturers at PHEIs into mechanical course groups and selected those with more than 5 years of teaching experience.

The main tool for data collection in this study is a questionnaire instrument administered through Google Forms. The measurement scale used in this study is a five-point Likert scale. According to Heo et al. (2022), the Likert scale remains relevant when researchers intend to gather data from respondents accustomed to using this scale, as it is widely employed in previous research. Every study needs to establish validity to meet its research objectives. Therefore, two experts in the field of digital technology were selected to oversee this validation process. According to Lee Abdullah and Wei (2017), research instruments should be reviewed to ensure that the questions formulated are suitable and aligned with the study's objectives. Pilot study is the initial step in any research, typically smaller in scale, aimed at aiding in the planning and refinement of the main study. To assess the reliability of an instrument, a pilot study is being conducted. This pilot study involved lecturers from PHEIs specialising in TVET learning systems. Validation and reliability processes are essential prerequisites before embarking on any study (Daud et al., 2017). The data obtained by the researcher was analysed descriptively. The researcher utilised the Statistical Package for the Social Sciences (SPSS) version 26 to analyse the data obtained from the respondents. The outcome of findings were presented as frequency, percentage, mean values, standard deviation, and ANOVA. From the pilot study, the

researcher determined that Cronbach's alpha values for the three constructs were at a good level, namely 0.808, 0.786, and 0.816. These three constructs comprised items that assessed the digital ability of TVET lecturers.

4. Results

Table 1 below shows the distribution of respondent profiles categorised by demographics, including age, gender, highest education level, PHEIs and teaching experience.

Table 1: Distribution of Respondents by Demographics

Personal information		Frequency (*f*)	Percentage (%)
Gender	Male	77	72.0
	Female	30	28.0
Age	31-35	20	18.9
	36-40	44	41.5
	41-45	16	15.1
	46 years old and above	26	24.5
Highest Education Level	Master's Degree	23	21.5
	Doctor of Philosophy (Ph.D.)	84	78.5
Public Higher Education	UniMAP	37	34.6
	UMP	8	7.5
	UTeM	18	16.8
	UPSI	7	6.5
	UPM	3	2.8
	UTHM	16	15.0
	UTM	18	16.8
Teaching Experience	6-10 Years	40	37.4
	11-15 Years	42	39.3
	16-20 Years	13	12.1
	21-35 Years	12	11.2

The majority of respondents were male, totalling 77 individuals (72%), while females accounted for 30 individuals (28%). In terms of age, 20 respondents were aged 31-35 years old, and 26 respondents were 46 years old and above. Among the respondents, 84 individuals (78.5%) achieved Ph.D. as their highest educational qualification, while 23 respondents (21.5%) attained Master's degree. In terms of institutions (PHEI), the majority of respondents were from UniMAP, totalling 37 individuals (34.6%). UMP, UPSI, and UPM each had fewer than 10 respondents, specifically 8, 7, and 3 individuals respectively (7.5%, 6.5%, 2.8%). UTM and UTeM had an equal number of respondents, totalling 18 individuals each (16.8%). UTHM had 16 respondents (15.0%). In terms of teaching experience, 12 respondents (11.2%) had 21 years and above of teaching experience. Meanwhile, 95 respondents (88.8%) had teaching experience of 20 years and below.

4.1. Level of Competence Among PHEIs Lecturers in the Use of Technology and Automation

Referring to Table 2, the overall average mean score for the competence level among PHEI lecturers in the use of technology and automation is 3.83, indicating a high level. Specifically, the mean score for knowledge among TVET lecturers is 3.94 (SD = 0.472). 31 respondents (29.0%) have a moderate level, while 76 respondents (71.0%) exhibit a high level of competence in terms of knowledge. For the skills aspect, the overall mean score is 3.54 (SD = 0.611), indicating a moderate level. 58 respondents (54.2%) are at a moderate level, with only 3 respondents (2.8%) at a low level. 46 respondents (43.0%) are at a high level. In terms of attitudes, the overall mean score is 4.05 (SD = 0.534), indicating a high level. 25 respondents (23.4%) are at a moderate level, while 82 respondents (76.6%) are at a high level.

Table 2: Level of Competence among PHEIs Lecturers in the Use of Technology and Automation

Competence	N	M	SD	Low *f* (%)	Moderate *f* (%)	High *f* (%)
Knowledge	107	3.94	0.472	0 (0.0)	31 (29.0)	76 (71.0)
Skills	107	3.54	0.611	3 (2.8)	58 (54.2)	46 (43.0)
Attitude	107	4.05	0.534	0 (0.0)	25 (23.4)	82 (76.6)
Overall	107	3.83	0.536		High	

4.2. Constructs of Competence Among PHEIs Lecturers in the Use of Digital Technology & Automation

Table 3 displays the average scores for the constructs of competence among PHEI lecturers in the use of digital technology & automation. From the analysis conducted, the researcher found that there are 3 constructs with moderate levels: Additive Manufacturing, Autonomous Robots, and Simulation (M = 3.54, SD = 0.830; M = 3.35, SD = 0.691; M = 3.62, SD = 0.691). For Additive Manufacturing, 8 respondents (7.5%) were at a low level while 47 respondents (43.9%) were at a moderate level, and another 52 respondents (48.6%) were at a high level. Cloud Computing had the highest mean score compared to the other constructs, with M = 4.28 (SD = 0.512). A total of 92 respondents (86.0%) were at a high level, while 15 respondents (14.0%) were at a moderate level. The lowest overall mean score was for the Autonomous Robot construct at 3.35 (SD = 0.691). This construct had 7 respondents (6.5%) at a low level, 62 respondents (57.9%) at a moderate level, and 38 respondents (35.5%) at a high level.

Table 3: Level of Competence among PHEIs Lecturers in the Use of Technology and Automation

Pillars of IR 4.0	M	SD	Low *f* (%)	Moderate *f* (%)	High *f* (%)
Cloud Computing	4.28	0.512	0 (0.0)	15 (14.0)	92 (86.0)

Additive Manufacturing	3.54	0.830	8 (7.5)	47 (43.9)	52 (48.6)
Augmented Reality	3.85	0.583	2 (1.87)	36 (33.6)	69 (64.5)
Cyber Security	3.79	0.603	1 (0.9)	40 (37.4)	66 (61.7)
Autonomous Robot	3.35	0.603	7 (6.5)	62 (57.9)	38 (35.5)
Internet of Things	4.05	0.543	0 (0.0)	26 (24.3)	81 (75.7)
Simulations	3.62	0.645	4 (3.7)	58 (54.2)	45 (42.1)
Big Data	4.05	0.456	0 (0.0)	17 (15.9)	90 (84.1)
System Integration	3.71	0.506	1 (0.9)	49 (45.8)	57 (53.27)
Total	3.80	0.597		High	

4.3. Significant Competency Differences Among PHEI Lecturers Based on Teaching Experience

Table 4 shows the competency differences among lecturers based on teaching experience. Lecturers with 6-10 years of teaching experience scored a high minimum value of 3.88 (SD = 0.495). Lecturers with 11-15 years of teaching experience obtained a minimum score of 3.86 (SD = 0.425). Meanwhile, lecturers with 16-20 years of teaching experience had a minimum score of 3.65 (SD = 0.284). Finally, lecturers with 21-35 years of experience achieved a minimum score of 3.49 (SD = 0.530). The p-value in Table 4 is less than 0.05, indicating significant differences in competencies among TVET lecturers based on teaching experience.

Table 4: Significant Differences in Competencies Among Lecturers in PHEI based on Teaching Experience.

Teaching Experience	N	M	SD	F	sig
6-10 years	40	3.88	0.495	3.041	0.032
11-15 years	42	3.86	0.425		
16-20 years	13	3.65	0.284		
21-35 years	12	3.49	0.530		
Total	107	3.80	0.465		

5. Conclusion

Overall, the study findings indicate that the competency level of TVET lecturers at PHEIs in utilising digital technology and automation is high. These findings suggest that TVET lecturers at PHEIs possess good and efficient competencies and are prepared to face the IR 4.0. IR 4.0 in the education sector is expected to yield positive outcomes, fostering proficiency among students in digital and automation technologies. The application of IR 4.0 technologies such as smart classrooms and smart campuses will provide an engaging experience to attract students' interest in facing the PAK-21 challenges. This is consistent with the goals outlined in the Malaysian Education Development Plan 2015-2025 (Higher Education), which encourages lecturers to implement changes or innovations in their teaching strategies.

Lecturers' competencies need to align with current changes, particularly in interactive learning applications. The findings of this study can contribute new insights into the level of competency among educators in using digital technology and automation. Therefore, the researcher hopes that these findings can provide pertinent insights on the adoption and implementation of digital technology and automation in preparation for IR 4.0.

The effectiveness of educational innovations, including the use of digital technology and automation, relies heavily on the role of educators. However, there are also other factors that influence the effectiveness of reforms and the implementation of policies. The researcher hopes that educators can transform their teaching and learning approaches to produce students who can adapt to PAK-21 and fulfil the aspirations of the Malaysian Education Development Plan 2015-2025 (Higher Education), as well as face the challenges of IR 4.0.

Ethics Approval and Consent to Participate

The researchers obtained ethical permission from Guideline for Non-Clinical Research Ethics Universiti Teknologi Malaysia. This study followed the institutional research committee's ethical criteria for human participants. All participants provided informed consent.

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Conflict of Interest

The authors reported no conflicts of interest for this work and declare that there is no potential conflict of interest with respect to the research, authorship, or publication of this article.

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