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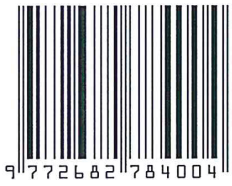

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DIGITAL COMPETENCY FRAMEWORK IN DIGITAL TECHNOLOGY TOWARDS FUTURE INDUSTRIAL REVOLUTION IN MALAYSIA

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ABSTRACT

This study aimed to identify the digital competency domains and elements essential for IT graduates in Malaysia and to develop a specialized digital competency framework for future graduates. A quantitative approach was used, involving surveys across five polytechnics for pilot research, followed by data collection from ten polytechnics, with results validated through confirmatory factor analysis (CFA). The study established a Digital Competency Framework for Polytechnic IT Graduates, comprising four domains: Personal Effective Competencies, Functional Competencies, Essential Competencies, and 4IR Competencies, encompassing 15 elements. The findings highlighted that two domains demonstrated a high level of digital competence, while one was at an average level. The research offers valuable insights into the digital competencies necessary for IT graduates and supports the development of an educational system better equipped to prepare students for the challenges of Industry 4.0 in Malaysia.

1. Introduction

The widespread adoption of technology is driving significant advancements in communication, development, and the workforce, leading many scholars to refer to it as the Fourth Industrial Revolution (IR4.0) (Corò & Volpe, 2020; Drath & Horch, 2014). In response, the

Malaysian government has initiated various efforts to strengthen human capital, with human resource development being a key focus of the 11th Malaysia Plan. This plan aims to create more job opportunities, maintain full employment, and reform labour market institutions, emphasising the importance of quality education and training through TVET (MBOT, 2018; Economic Planning Unit, 2015; Seameo Voctech, 2019).

Investing in education and training is essential for local governments to ensure future productivity and bolster the nation's capacity for growth (Giroth et al., 2023). Transforming human capital incrementally is critical to avoiding potential shortages in future industries (Qureshi, 2023). The impact of IR4.0 on production, labour markets, and education has led to the creation of new jobs while older roles are replaced by those driven by emerging technologies (Su et al., 2022). Malaysia, however, remains heavily reliant on unskilled and semi-skilled labour, contributing to persistent high unemployment rates (Economic Planning Unit, 2015; Fateh, Mohamed, & Omar, 2022). The ICT sector is vital to addressing this issue (Baker, 2016), yet unemployment among IT and Computer Science graduates remains a concern. To tackle these challenges, IT professionals must enhance their holistic ICT skills and specialised approaches (Al-Daajeh et al., 2022). This study seeks to address the existing gap by identifying the key digital skills and competencies necessary for IT graduates to thrive in the future job market.

2. Industrial Revolution 4.0 and Digital Competency

The evolution of industrial revolutions, from the mechanisation of the 1st to the rise of electronics and automation in the 3rd, has culminated in the ongoing Industrial Revolution 4.0 (IR4.0), which is reshaping industries through smart manufacturing and technologies like the Internet of Things (IoT), Big Data, and cybersecurity (Darma et al., 2020; Wong & Hazley, 2020; Ali et al., 2023). IR4.0 represents a significant shift, integrating information and communication technologies into industrial processes, leading to automation and the creation of cyber-physical systems (Pfeiffer, 2015; Modoni et al., 2019). The advent of this revolution demands a workforce adept at navigating these new technologies, as industries increasingly rely on high-skilled employees with multidisciplinary competencies to keep pace with rapid technological advancements (Shi & Bangpan, 2022).

As IR4.0 continues to transform production, labour markets, and educational systems, the need for a digitally competent workforce becomes critical. Disruptive technologies in the ICT sector are making many traditional jobs obsolete, while simultaneously creating new roles that require advanced digital skills (Rathfelder, 2015; Souto-Otero, Brown, & Freebody, 2023). This shift has led to an increased demand for workers proficient in areas like problem-solving, teamwork, and digital literacy, while the demand for low-skilled labour decreases (Winterton & Turner, 2019; Chen et al., 2024). Addressing these challenges, higher education institutions must focus on equipping students with the necessary digital competencies, emphasising not only technical skills but also the ability to adapt to and critically evaluate new technologies (Ho et al., 2022).

To meet the evolving demands of IR4.0, developing a comprehensive digital competency framework is essential, particularly for IT graduates who must be prepared for the future job market. This framework should integrate various aspects of digital competence, including technical, cognitive, ethical, and integrated components (Calvani et al., 2008; Ilomäki et al., 2011). By aligning education with industry needs, higher education can play a crucial role in bridging the gap between academic knowledge and practical skills, ensuring that graduates are not only technically proficient but also capable of navigating and leveraging the advancements of IR4.0 (Cheng et al., 2021; Sidhu, Abdullah & Jalil, 2024).

3. Methodology

Confirmatory factor analysis (CFA) was conducted to validate the data collection strategy used in this quantitative study, which involved surveys. A total of 253 participants responded to the questionnaire. The CFA aimed to test the stability and accuracy of the model generated by the latent variables identified in the exploratory factor analysis (EFA), as recommended by Knekta, Runyon, & Eddy (2019). The CFA assessed convergent, construct, and discriminant validity, enabling the calculation of valid instrument values (Baistaman et al., 2020). Convergent validity, which evaluates the extent to which indicators within a single construct correlate, was measured using the Average Variance Extracted (AVE). Convergent validity is achieved when the AVE for a construct exceeds 0.5, indicating that the items are statistically significant. Additionally, Composite Reliability (CR) was used to evaluate the internal consistency and reliability of each construct, with a CR value above 0.6 considered acceptable (Awang, 2012).

Construct validity was established when the Fitness Indexes of a construct met the required threshold. These indexes assessed how well the items corresponded to their respective latent constructs. Several Fitness Indexes have been proposed in previous studies to evaluate the model's fit. According to Hair et al. (2021), if the sample size exceeds 200, the chi-square p-value as an absolute fit index can be disregarded. Discriminant validity, which ensures that the measurement model is free from redundant items, was assessed using Modification Indices (MI). A high MI value indicated redundancy among items, giving researchers the option to either remove the redundant items or treat them as free parameter estimates. Additionally, for discriminant validity, the correlation between exogenous constructs should not exceed 0.85 to avoid redundancy or serious multicollinearity issues (Awang, 2012).

4. Results

The measurement model is a representation of the measurement theory, illustrating how constructs are operationalized through a set of measured variables. In this study, a second-order measurement model analysis was conducted to assess the goodness of fit for the structural model. This analysis was performed on the entire study sample, consisting of 253 participants, to evaluate the suitability of the developed model structure. The results of this analysis are depicted in Figure 1.

Figure 1 reveals that all four domains and 15 elements contributed significantly, with standardised loading values exceeding 0.60, to the digital competencies of Polytechnic IT graduates. The model also met the required fitness indexes, with CMIN/df = 1.283, CFI = 0.966, GFI = 0.935, AGFI = 0.900, TLI = 0.969, NFI = 0.924, and RMSEA = 0.063. Based on these results, the overall construct was tested, confirming that the measurement model meets the necessary conditions. This indicates that the model is a reliable fit for the Digital Competency Model, which comprises four domains and 15 elements.

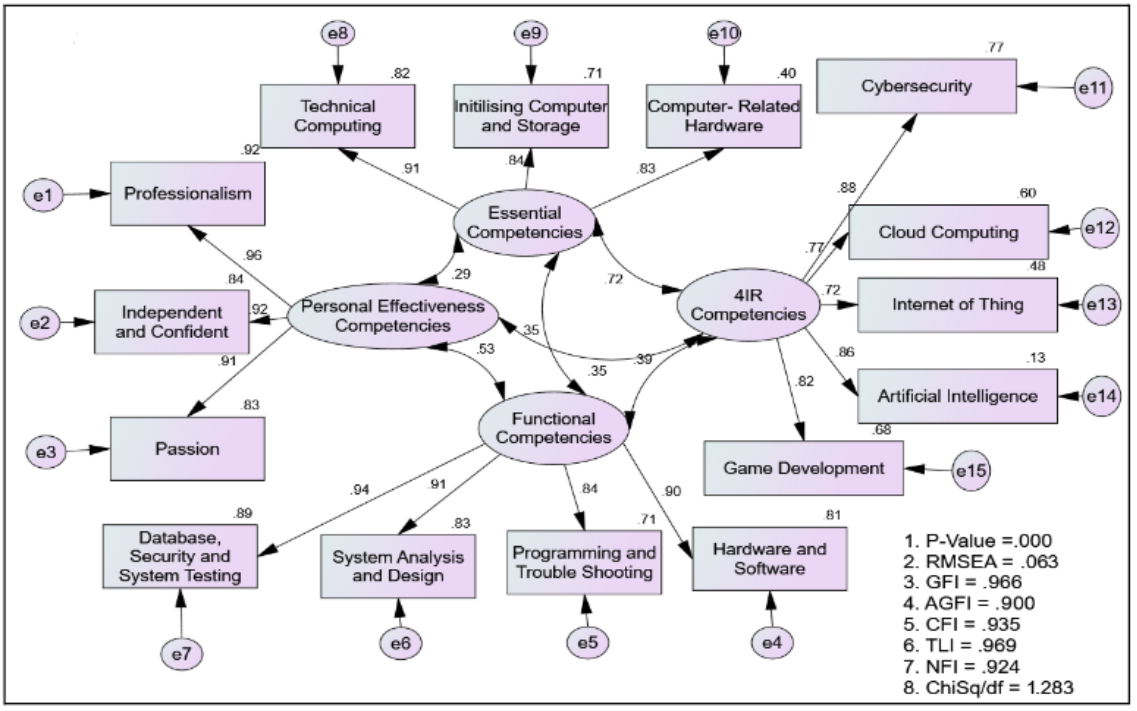

Figure 1. Digital Competency Framework for Polytechnics IT Graduates'

The study then proceeded to assess Convergent Validity. The AVE showed that each component had a value between 0.66 to 0.865 and CR for all constructs are computed and the values are more than 0.8 as shown in the Table 1 below.

Table 1
Average Variance Extracted (AVE) and Composite Reliability (CR**)**

Items	**Standardised Loading**	**SMC**	**CR**	**AVE**
Personal Effectiveness Competencies			0.951	0.865
Professionalism	0.96	0.922		
Independent & Confident	0.92	0.846		
Passion	0.91	0.828		
Functional Competencies			0.943	0.807
Database, Security and System Testing	0.94	0.884		
System Analysis and Design	0.91	0.828		
Programming and Troubleshooting	0.84	0.706		
Hardware and Software	0.90	0.810		
Essential Competencies			0.895	0.741
Technical Computing	0.91	0.828		
Initilising Computer and Storage	0.84	0.706		
Computer-Related Hardware	0.83	0.689		

4IR Competencies			0.906	0.666
Cloud Computing	0.77	0.593		
Cybersecurity	0.88	0.774		
Internet of Thing	0.72	0.518		
Artificial Intelligence	0.86	0.740		
Game Development	0.82	0.672		

Based on the AVE and CR values presented in Table 1, all constructs have surpassed their respective thresholds of 0.5 for AVE and 0.6 for CR. These results indicate that convergent validity and composite reliability have been successfully achieved for all constructs within the model. Discriminant validity, which measures how distinct a concept is from other concepts, was also assessed. To meet the criteria for discriminant validity, the diagonal values in bold must be higher than the other values in the corresponding row and column. This assessment is crucial to ensure that the concepts are not redundant. As shown in Table 2, the Discriminant Validity Index Summary confirms that all constructs have successfully met the criteria for discriminant validity.

Table 2
The Discriminant Validity Index Summary

Construct	PEC	FC	EC	4IRC
PEC	**0.930**			
FC	0.530	**0.898**		
EC	0.292	0.351	**0.861**	
4IRC	0.350	0.393	0.724	**0.816**

As a result, the study identified the necessity for a Digital Competency Framework tailored for Polytechnic IT graduates to help guide and standardise their competencies. This framework encompasses four key domains: Personal Effectiveness Competencies, Functional Competencies, Core Competencies, and 4IR Competencies. Comprising 15 specific elements, the quantitative analysis revealed that two of the domains demonstrated a high level of digital competence, while one was found to be at an average level. Confirmatory factor analysis (CFA) validated that these four dimensions were effectively represented by their respective domains and elements. The overall development of the framework is illustrated in Figure 2.

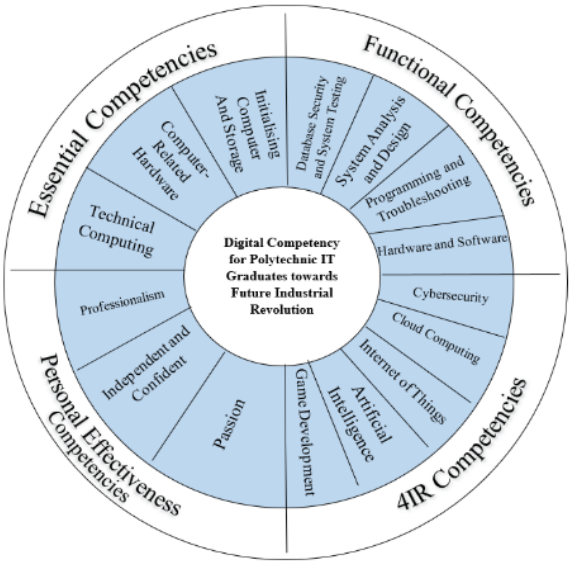

Figure 2. Digital Competency Framework for Polytechnics IT Graduates'

5. Discussion

The findings of this study provide valuable insights into the development of a Digital Competency Framework designed specifically for Polytechnic IT graduates. The measurement model used in this research successfully demonstrates how digital competencies can be operationalized through various constructs. The second-order measurement model analysis confirmed that the developed framework is a good fit for assessing the digital competencies of these graduates.

The analysis revealed that all four domains and their corresponding elements play a significant role in shaping the digital competencies of Polytechnic IT graduates. The model's overall fit was strong, indicating that the framework is a reliable representation of the competencies necessary for success in the digital economy. The positive results of convergent and discriminant validity assessments further confirm that the constructs within the model are both distinct and consistently measured, ensuring that the framework is robust and free from redundancy.

The study identified four key domains—Personal Effectiveness Competencies, Functional Competencies, Core Competencies, and 4IR Competencies—that are essential for guiding and standardising the digital skills of Polytechnic IT graduates. The analysis showed that while some domains exhibit a high level of digital competence, others present opportunities for enhancement, suggesting areas where curriculum and training programs can be improved. As for that, the developed Digital Competency Framework offers a comprehensive and practical tool for preparing Polytechnic IT graduates for the challenges of the Fourth Industrial Revolution (IR 4.0). By aligning educational outcomes with industry demands, this framework ensures that graduates possess the necessary skills to thrive in a rapidly evolving digital landscape. Future research should focus on refining the framework and exploring its applicability in various contexts to maintain its relevance and effectiveness in equipping IT graduates for the workforce.

6. Conclusion

Enhancing the reputation and value of IT graduates in Malaysia has become a priority for industry experts, especially given the critical role of digitalization in IR 4.0. Reskilling and upskilling the workforce are essential, particularly for preparing the next generation to meet the demands of the evolving job market. To equip workers with the necessary competencies for this new environment, it is crucial for all stakeholders—including industry leaders and educational institutions—to support the MOHE's initiatives to transform technical and vocational education. The findings of this study are anticipated to contribute to the enhancement of IT curricula and systems at Polytechnics, thereby enriching the collective knowledge base. Future research should expand on this study by refining its concepts and perspectives, regularly updating digital competencies, and ensuring alignment with Malaysia's digital development strategies, including the government's digital transformation efforts through MITI.

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Authors Contributions

All authors contributed to developing ideas and the submission process.

Conflict of Interest

There is no conflict of interest because of this study.

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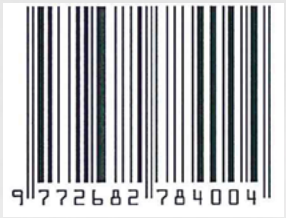

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