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EXPLORING DIGITAL COMPETENCY KNOWLEDGE AMONG MALAYSIAN UPPER SECONDARY STUDENTS: A LOCALITY-BASED RASCH MODEL ANALYSIS

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Abstract: *Digital competency is a crucial skill for navigating modern academic and societal demands. However, disparities in access to digital resources have led to uneven competency levels among students, particularly across different localities. This study aimed to explore the knowledge dimension of digital competency among Malaysian upper secondary students using a locality-based approach. A quantitative research design was employed involving 300 Form Four students from urban and rural schools across five Malaysian states, selected through stratified random sampling. Data were collected using a 47-item multiple choice instrument covering seven constructs of digital competency knowledge and analyzed using the Rasch Measurement Model. The results demonstrated high person reliability (0.94) and item reliability (0.98), indicating the instrument's strong psychometric properties. Urban students exhibited higher levels of digital competency knowledge compared to rural students, highlighting a persistent digital divide. The findings provide empirical evidence for developing targeted educational policies and interventions to enhance digital equity and inform future expansion of the digital competency framework.*

Keywords: *Digital competency, Rasch Measurement Model, upper secondary students, urban-rural divide, digital literacy.*

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Introduction

In today's rapidly evolving digital landscape, digital competency has become an essential skill for students to navigate both academic and real-world challenges (Ibatova, 2021; Nikou & Aavakare, 2021). As technology continues to transform education, students are expected to possess adequate digital knowledge to maximize learning opportunities, engage in critical thinking, and adapt to new technological advancements. However, the level of digital competency among upper secondary students in Malaysia remains a subject of debate, with disparities observed based on locality and access to digital resources (Ilomäki et al., 2023). Research indicates that while students are increasingly exposed to digital tools, their ability to effectively utilize these tools for academic and problem-solving purposes varies significantly. Rural students may face limitations due to inadequate infrastructure, lack of exposure, and limited digital literacy programs (Mei et al., 2023). Despite the emphasis on digital learning in the Malaysian education system, no fully standardised, psychometrically validated instrument tailored specifically to assess the multi-dimensional digital competencies such as problem-solving with digital tools, digital content creation, information and data literacy, digital safety, nor digital citizenship among upper secondary students across diverse localities. (Marín & Castañeda, 2023). The absence of such a holistic, nationwide measurement instrument hinders educators and policymakers from identifying specific competency gaps and from designing targeted, location-sensitive interventions to bridge the digital divide.

This study aims to explore digital competency knowledge among Malaysian upper secondary students using a locality-based approach. By employing the Rasch Measurement Model, this research seeks to provide a robust analysis of students' digital competency levels while considering differences between urban and rural school settings. The findings will contribute to a deeper understanding of digital literacy disparities and offer insights into designing more effective digital competency frameworks tailored to students' needs.

The significance of this study lies in its potential to inform educational stakeholders about the strengths and weaknesses of digital competency development among students. By leveraging empirical evidence from the Rasch analysis, this research can aid in formulating strategies to enhance digital literacy, improve curriculum design, and ensure equitable access to digital education for all students, regardless of their locality (Johnson et al., 2021; Laufer et al., 2021).

Literature Review

Digital competency has been conceptualized through several international frameworks such as the European DigComp model (van Laar et al., 2020; Marín & Castañeda, 2023), which emphasizes multiple dimensions including information and data literacy, digital content creation, communication, problem solving, and digital safety. These models serve as important references for local adaptation in Malaysia, where contextual factors such as rural–urban disparities and infrastructural limitations shape students' digital experiences (Ilomäki et al., 2023; Mei et al., 2023). For the purpose of this study, Digital Competency Model For Upper Secondary Students' in Malaysia (Ghafar et al., 2025) was adopted as the theoretical foundation to develop the instrument. The model comprises seven constructs, namely digital technology applications, digital problem solving, interpersonal skills, data and information literacy, digital content creation, digital security, and digital citizenship, which collectively provide a comprehensive framework for assessing students' digital competency knowledge. By grounding the instrument in this model, the study ensures that the items developed are contextually relevant to Malaysian upper secondary students while aligning with international digital competency frameworks.

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The development of items to measure digital competency requires a systematic process grounded in literature review and expert validation to ensure construct coverage and contextual relevance (Azrilah et al., 2015; Ramli, 2019). For content validation, Lawshe's (1975) Content Validation Ratio (CVR) is widely adopted as a quantitative method to evaluate the relevance of items based on expert judgment, thereby strengthening the instrument's content validity (Kamis et al., 2014). Beyond expert review, pilot testing is essential to refine item clarity and functionality, ensuring that the instrument captures the intended constructs effectively before large-scale use. To further establish psychometric soundness, the Rasch Measurement Model is employed, as it provides robust evidence of item reliability, validity, and dimensionality by converting ordinal responses into interval-level data, thereby enabling more precise measurement of latent traits (Bond & Fox, 2015; Boone, 2016). Unlike classical test theory, Rasch analysis allows for detailed diagnostics of item functioning, including fit statistics, item and person maps, separation indices, and unidimensionality tests, which are critical for determining whether an instrument measures a single underlying construct consistently (Linacre, 2006; Tennant & Küçükdeveci, 2023). In the Malaysian educational context, Rasch analysis has been increasingly recognized as a rigorous method for developing and validating instruments, particularly in studies related to digital literacy and competency assessments, as it ensures fairness, precision, and comparability across diverse student populations (Arifin et al., 2021; Azrilah et al., 2015). By combining the Faeeza Digital Competency Knowledge Model as the theoretical foundation, systematic item development through literature review, expert validation using the Content Validation Ratio (CVR), two rounds of pilot testing, and Rasch measurement analysis, this study ensures that the developed instrument achieves a high level of content and construct validity, reliability, and generalizability. Such a methodological approach not only strengthens the psychometric quality of the tool but also provides policymakers and educators with a valid and contextually relevant instrument to assess digital competency knowledge among Malaysian upper secondary students.

Method

This study employs a quantitative descriptive method to examine digital competency knowledge among secondary school students in Malaysia. The study sample was selected through stratified random sampling, involving 300 students from urban and rural secondary schools in the states of Kedah, Perak, Johor, Terengganu, and Sarawak. This sample size is deemed sufficient based on the sample determination requirements established in the Rasch Measurement Model (1993), as stated by (Linacre, 1994).

At the first stage of sampling, all states in Peninsular Malaysia were divided into five zones based on their geographical location: Northern Zone, Central Zone, Southern Zone, East Coast Zone, and Borneo Zone. In the second stage, one state from each zone was randomly selected, resulting in the selection of Kedah, Perak, Johor, Terengganu, and Sarawak. Subsequently, two secondary schools from urban and rural localities were randomly selected to represent each zone. Finally, 15 Form Four students from each selected secondary school were randomly chosen to participate in this study. The details of the sampling process are illustrated in Figure 1.

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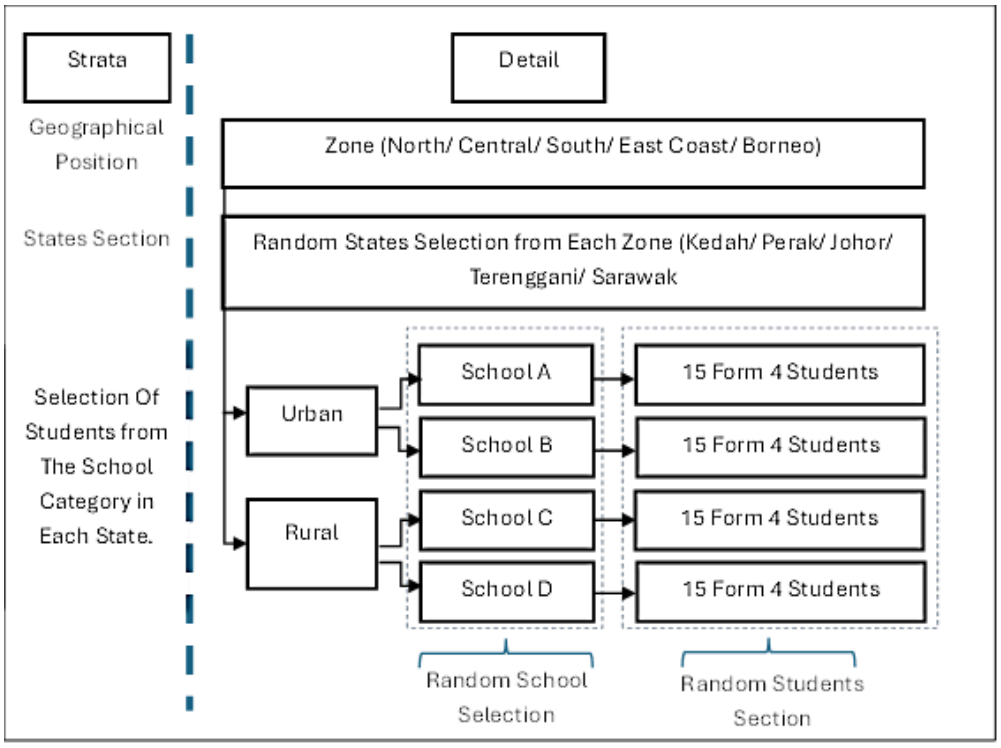

Figure 1: Stratified Random Sampling of in a Field Study

The data collection technique in this study involved a questionnaire consisting of 47 items covering seven main constructs within the dimension of digital competency knowledge (refer to Table 1). This instrument was developed based on a comprehensive literature review and validated by experts in the relevant field to ensure content validity. The expert validation process employed the Content Validation Ratio (CVR) to determine the relevance and clarity of each item. In addition, the instrument was piloted twice to refine its structure and items, thereby ensuring a high level of validity and reliability before being administered in the actual field study. The questionnaire was designed in a multiple-choice format, where each item was structured to measure the level of digital knowledge among the selected respondents through an appropriate sampling method.

Table 1: Number of Items by Construct

Construct	Number of Items
Digital Technology Applications	6
Digital Problem Solving	7
Interpersonal Skills	8
Data and Information Literacy	4
Digital Content Creation	7
Digital Security	7
Digital Citizenship	8

The research data was analyzed using the Rasch Measurement Model. This model was chosen because it is a 1PL model within Item Response Theory (IRT), which considers only one item parameter that is difficult. Through this model, raw data can be transformed into interval-level measurements by ranking individuals based on their ability levels and arranging items according to their difficulty levels (Bond & Fox, 2015; Davis & Boone, 2021). The Rasch

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Measurement Model offers several key advantages. First, it enables the construction of a linear scale with equal intervals, allowing ordinal data, such as Likert scale responses, to be converted into interval data in the form of Log Odds Units (Logits). Second, it effectively handles missing data by producing accurate estimates and identifying discrepancies between observations and expectations. Finally, this model creates a standardized measurement scale, allowing repeated measurements of latent traits and making it reusable in various studies (Azrilah Abdul Aziz et al., 2015).

Result

Based on the Rasch analysis conducted for person (refer to Figure 2), the study results indicate that the instrument used has high reliability and functions effectively in measuring individual ability. The Person Reliability value obtained is 0.94, which demonstrates that the instrument has very high reliability in consistently assessing individual abilities (Bond & Fox, 2015; Linacre, 2006). In addition, the Person Separation value is 3.97, meaning that the instrument can differentiate individuals into nearly four distinct ability categories, indicating its strong capability in classifying respondents' ability levels (Boone, 2016). In terms of Person Measure, the average value obtained is 0.42 logit, suggesting that, overall, the individuals involved in this study possess a higher ability level compared to the item difficulty level in the instrument (Fisher, Jr., 2003). The range of individual ability measures spans from -3.92 logit to 4.37 logit, indicating significant variability in respondents' ability levels.

The suitability of the Rasch model is also supported by the Mean-Square Fit (MNSQ) values for Infit and Outfit, which fall within the acceptable range (0.6 to 1.4) (Bond & Fox, 2015; Kamis et al., 2014). The average Infit MNSQ value is 1.01, while the Outfit MNSQ value is 0.99, indicating no major deviations in individual response patterns. The ZSTD values for Infit and Outfit also fall within the acceptable range (-2.00 to +2.00), further confirming the data's alignment with the Rasch model (Linacre, 2006).

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	25.9	47.0	.42	.45	1.01	.09	.99	.02
SEM	.8	.0	.12	.01	.01	.04	.04	.04
P.SD	12.9	.0	1.99	.18	.14	.75	.63	.71
S.SD	12.9	.0	1.99	.18	.14	.75	.64	.71
MAX.	46.0	47.0	4.47	1.02	1.45	2.38	6.94	2.43
MIN.	2.0	47.0	-3.92	.34	.67	-1.89	.18	-1.71
REAL RMSE	.50	TRUE SD	1.93	SEPARATION	3.85	Person RELIABILITY	.94	
MODEL RMSE	.49	TRUE SD	1.93	SEPARATION	3.97	Person RELIABILITY	.94	
S.E. OF Person MEAN = .12								

Figure 2: Rasch Analysis for Person

Meanwhile, the Rasch analysis of the items (refer Figure 3) also indicates that the instrument used has a very high level of reliability in accurately measuring individual ability. The Item Reliability value obtained is 0.98, which demonstrates that the instrument has very high stability and consistency in assessing item difficulty (Bond & Fox, 2015; Linacre, 2004). Additionally, the Item Separation value is 7.48, indicating that the instrument can differentiate items into nearly seven distinct difficulty levels, reflecting the excellent quality of the items (Boone, 2016; Ramli, 2019). In terms of Item Measure, the average value obtained is 0.19 logit, suggesting that the difficulty of the items in this instrument is nearly balanced with the ability of the

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individuals tested (Fisher, Jr., 2003). The range of item difficulty measures spans from -3.80 logit to 2.42 logit, indicating variation in the difficulty levels of the items tested. The validity of the Rasch model is further supported by the Mean-Square Fit (MNSQ) values for Infit and Outfit, which fall within the acceptable range (0.60 to 1.40) (Arifin et al., 2021; Bond & Fox, 2015). The average Infit MNSQ value is 1.00, while the Outfit MNSQ value is 0.98, demonstrating that the items in this instrument function well without significant deviations in response patterns. Additionally, the ZSTD values for Infit and Outfit fall within the acceptable range (-2.00 to +2.00), confirming the alignment of the data with the Rasch model (Linacre, 2006).

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	174.6	300.0	.00	.17	1.00	-.02	.99	-.21
SEM	7.1	.0	.19	.00	.03	.28	.07	.21
P.SD	48.4	.0	1.30	.02	.18	1.93	.49	1.44
S.SD	48.9	.0	1.31	.02	.18	1.95	.50	1.46
MAX.	284.0	300.0	2.42	.29	1.50	4.66	3.11	4.15
MIN.	82.0	300.0	-3.80	.15	.63	-4.51	.37	-2.56

REAL RMSE .17 TRUE SD 1.29 SEPARATION 7.48 Item RELIABILITY .98
MODEL RMSE .17 TRUE SD 1.29 SEPARATION 7.72 Item RELIABILITY .98
S.E. OF Item MEAN = .19

Figure 3: Rasch Analysis for Item

Overall, these findings indicate that the instrument used is stable of high quality, and capable of accurately measuring item difficulty while effectively distinguishing between items. The analysis of item difficulty levels and respondents' abilities in the knowledge dimension of the Digital Competency (refer to Figure 4) found that the most difficult item was item B3.1P (+2.42 logit). A total of 20 out of 300 respondents, comprising 12 respondents from urban areas and 8 respondents from rural areas, answered all questions correctly, with an ability measure of +5.71 logit. Additionally, 54 respondents had an ability level higher than the most difficult item (+5.71 to +2.43 logit). Based on locality, 28 respondents were from urban areas, while 26 were from rural areas. The item with the lowest difficulty measure was item C1.2P (-3.80 logit). There were three respondents with ability levels below the lowest item measure (-3.92 logit), consisting of one respondent from an urban area and two respondents from rural areas.

The study found that 32% of urban respondents and 28% of rural respondents fell into the group with good digital competency knowledge. Meanwhile, 16.3% of urban respondents and 20.6% of rural respondents fell into the group with low digital competency knowledge. Based on the analysis conducted, it can be concluded that respondents from urban areas performed better than respondents from rural areas in terms of digital competency knowledge.

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Figure 4:Analysis Of Item Difficulty Levels And Respondents' Abilities In The Knowledge Dimension Of The Digital Competency

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Discussion

Based on the Rasch The findings of this study indicate that the developed instrument exhibits a high degree of reliability, as evidenced by the Person Reliability (0.94) and Item Reliability (0.98) values. These values confirm the instrument's ability to consistently and accurately measure individual abilities and item difficulties, aligning with contemporary psychometric research (Tennant & Küçükdeveci, 2023). Additionally, the Person Separation Index (3.97) and Item Separation Index (7.48) further validate the instrument's robustness, as a separation index above 2.0 is considered indicative of a well-functioning measurement model (Boone, 2016).

The distribution of respondent ability levels, ranging from -3.92 to 4.37 logits, and item difficulty values from -3.80 to 2.42 logits, suggests that the instrument effectively differentiates digital competency levels among students. This aligns with contemporary findings emphasizing that a well-constructed Rasch measurement model should encompass a broad spectrum of abilities and item difficulties to enhance measurement precision (Effatpanah et al., 2024). Moreover, the Mean-Square Fit (MNSQ) Infit and Outfit values falling within the acceptable range of 0.6 to 1.4, along with ZSTD values between -2 and +2, confirm an adequate model fit with no significant distortions, consistent with recent validation studies in digital competency assessment (Mâsse et al., 2006).

These findings are consistent with recent research on Rasch model applications in educational assessments. (Boone, 2016) emphasized that reliability values exceeding 0.90 indicate strong measurement consistency, reinforcing the robustness of this study's instrument. Additionally, (Tennant & Küçükdeveci, 2023) noted that item separation indices above 3.0 reflect a high level of item differentiation, further supporting the validity of the developed measure.

A key finding of this study is the variation in digital competency levels between urban and rural students, with 32% of urban students displaying high competency levels, compared to 28% of rural students. This finding aligns with recent studies indicating that digital competency is influenced by socio-economic and infrastructural disparities (van Laar et al., 2020). The digital divide extends beyond access to devices, encompassing disparities in digital engagement and literacy development (Car et al., 2019). These findings underscore the need for targeted interventions to bridge the urban-rural digital competency gap and ensure equitable access to digital education resources.

The validated instrument provides a systematic and objective framework for assessing students' digital competencies. More importantly, the results highlight the urgent need to address digital disparities, as unequal access to digital resources can exacerbate educational inequities (Selwyn et al., 2023). This study's findings reinforce existing evidence that limited digital access negatively impacts students' ability to develop essential digital skills, which are increasingly vital in modern education.

From a policy perspective, these findings offer critical insights for education policymakers in designing interventions to enhance digital literacy across diverse demographics. The OECD (2021) report emphasizes that structured digital training programs significantly improve students' competencies, particularly for those with restricted access to technology (Bravo et al., 2021). Thus, interventions such as equitable digital resource distribution, teacher digital training programs, and active student participation in technology-enhanced learning can play a pivotal role in narrowing the digital divide.

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Despite the robustness of the findings, this study acknowledges potential limitations often associated with sample size. However, the sample of 300 respondents is within an acceptable range for psychometric analysis, particularly when employing models such as the Rasch Measurement Model, which can yield reliable estimates even with moderate sample sizes. While some guidelines recommend samples exceeding 500 for optimal parameter stability (Toker & Seidel, 2023), several scholars have affirmed that a sample size of 200 to 300 can be sufficient for preliminary validation studies. Therefore, the findings from this study remain meaningful and informative. Nonetheless, future research may consider larger samples to further strengthen generalizability and robustness of the instrument.

Additionally, this study focused specifically on the assessment of knowledge-based digital competency, which represents a foundational component of students' overall digital capability. This deliberate focus was intended to establish a valid and reliable baseline measurement before expanding to broader dimensions. While recent research highlights that digital competency is a multifaceted construct including practical skills, ethical considerations, problem-solving in digital environments, and collaborative engagement (Sparks et al., 2016), (Oke & Fernandes, 2020). A phased approach to instrument development is both methodologically sound and strategically appropriate. By first validating the knowledge-based domain, this study lays essential groundwork for subsequent incorporation of practical and attitudinal elements. Future research should build on these findings by developing an integrated assessment framework that captures the full spectrum of digital competency, ensuring alignment with current theoretical and policy developments.

Conclusion

This study confirms that the developed instrument is both highly reliable and valid for assessing students' digital competencies. The strong psychometric properties, as demonstrated through Rasch measurement analysis, highlight its robustness in measuring digital literacy levels across diverse student populations. These findings reinforce the significance of Rasch analysis in educational assessment, offering a precise and systematic approach to evaluating digital competency.

Moreover, the study underscores the critical issue of digital disparities, particularly between urban and rural students. The observed differences in digital competency levels indicate that unequal access to technology and digital resources continues to influence students' learning outcomes. Addressing these disparities is essential to ensure equitable digital education, enabling all students to develop the necessary skills for academic and professional success in the digital age.

As digital competency becomes increasingly vital in modern education, future research should expand the scope of digital literacy assessments by incorporating broader determinants such as cultural influences, prior digital experiences, and institutional support for technology integration. Additionally, further validation of the instrument across different demographic groups and educational settings is necessary to enhance its generalizability and applicability. By doing so, researchers and policymakers can develop more effective strategies to bridge the digital divide and foster inclusive, technology-enhanced learning environments.

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