Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 11 Issue 44 (September 2026) PP. 296-315


**JOURNAL OF INFORMATION SYSTEM AND TECHNOLOGY MANAGEMENT (JISTM)**
www.gaexcellence.com/jistm

# BEYOND DIGITAL ACCESS: THE ROLES OF DIGITAL LITERACY AND PARTICIPATION IN PERCEIVED DIGITAL INFRASTRUCTURE READINESS

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**Article Info:**

**Article history:**
Received date: 30.07.2026
Revised date: 10.08.2026
Accepted date: 30.08.2026
Published date: 17.09.2026

**To cite this document:**

Mohamad, M., Kamaruddin, N. A., Hussain, N. M., & Asari, F. F. A. H. (2026). Beyond Digital Access: The Roles of Digital Literacy and Participation in Perceived Digital Infrastructure Readiness. *Journal of Information System and Technology Management, 11* (44), 296-315.

**Abstract:**

Digital transformation has become an integral part of regional socio-economic development; however, mere physical presence of digital infrastructure does not necessarily guarantee any substantial engagement with digital technologies. Utilizing the Technology Readiness Index (TRI) framework as the theoretical approach, this study assesses the impact of Digital Literacy, Digital Access, and Digital Participation/Learnability on Perceived Digital Infrastructure Readiness in Langkawi, Malaysia – popular international tourist attraction and emerging digital destination. A quantitative cross-sectional survey design with a quota sample was used for data collection. The data was collected from 248 adults, out of which 238 completed responses were included in the analysis after the process of data screening. Descriptive statistics, correlation analysis, and multiple linear regression were used for data analysis. Results suggest that all the three predictors show positive and statistically significant relationship with Perceived Digital Infrastructure Readiness in bivariate correlations. However, the multiple linear regression shows that Digital Participation/Learnability is the most significant predictor ( $\beta = 0.439$, $p < 0.001$), followed by Digital Literacy ( $\beta = 0.328$, $p<0.004$), while Digital Access did not have any significant independent impact ( $\beta = 0.205$, $p = 0.056$). It means that the perceptions about infrastructure readiness do not only depend on whether there is connectivity or equipment but also on individual

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JISTM
EISSN: 0128-1666
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capabilities to make use of and interact with technology. The main contribution of this paper is the development of an approach to digital readiness which is focused on people rather than on infrastructure. The implication from the results of the research for practice is that the regional digital strategy in touristic destinations should take into account both hardware and digital literacy factors.

**DOI:** 10.35631/JISTM.1144018

**Keyword:**

Digital Infrastructure Readiness, Digital Literacy, Digital Participation, Technology Readiness Index (TRI), People-Centred Digitalisation



## Introduction

In today's highly integrated world economy, digitization has progressed from being a competitive advantage to being an indispensable structural necessity. The earlier findings presented by Khan et al. (2025) and Nchise (2020) show that building up a conducive digital environment allows socio-political communities in developing countries and special economic zones to innovate, become more advanced in terms of governance and improve the quality of public services. Still, to measure the digital maturity of a region using hardware measures like fiber optics network, cell towers density, and basic bandwidth would be fundamentally inadequate; digital maturity presupposes a constant interaction between physical infrastructure of telecommunication and digital skills of the population at large (van Deursen & van Dijk, 2019).

For tourism-based island economies such as Langkawi in Malaysia, there is more contrast between the two sides. In recent times, considerable investments in digital infrastructure through state initiatives have been directed at Langkawi, which has seen the island become the first testbed for 5G technology in Malaysia as well as fast fibre installation as part of the National Digital Network initiative (Jalinan Digital Negara, JENDELA). While these initiatives have expanded hardware availability, existing empirical studies grounded in digital readiness and Parasuraman's (2000) Technology Readiness Index (TRI) have largely evaluated user readiness on cities or business organisations. (Attour & Chauvet, 2020; Cimbaljević et al., 2024; Mior Shariffuddin et al., 2023). More importantly, past studies have overlooked to recognize the implications of digital readiness in tourism-focused regional contexts where the two groups, visitors and local communities, rely on the same digital structure for distinct reasons and levels of competency. Moreover, current literature focuses primarily on intention

to adopt technology for particular business purposes rather than on the prediction of perceptions regarding regional technological readiness.

To resolve this conceptual and empirical gap, this study utilizes the basic assumptions of the Technology Readiness Index (TRI) by Parasuraman (2000). As opposed to using the four psychological factors of TRI (optimism, innovativeness, discomfort, and insecurity) directly as psychometric measurements, TRI serves as an interpretative frame for the current research. This study formulates the basic assumption of TRI, which is the idea that "user propensities and capabilities determine technological effectiveness" as an external socio-technical construct: Digital Access (availability), Digital Literacy (capability), and Digital Participation/Learnability (transactional engagement).

Importantly, this study changes the emphasis from objective benchmarks (such as download speed, latency, and coverage rate) or traditional measures of individual readiness. On the contrary, the study takes into consideration Perceived Digital Infrastructure Readiness as the dependent variable. Perceived Digital Infrastructure Readiness can be defined as an assessment that is done by users on the state of regional technological infrastructure and whether it is ready for carrying out various social, economic, and tourism tasks. Since user experience is what really matters in platform usage, this particular measure is crucial for assessing digital effectiveness.

Given the cross-sectional nature of the investigation, this study investigates how human capabilities and access predict rather than causally determine user evaluations of infrastructure readiness. The research is guided by three specific research objectives:

RO1: To examine the predictive relationship between Digital Literacy and Perceived Digital Infrastructure Readiness in Langkawi.
RO2: To examine the predictive relationship between Digital Access and Perceived Digital Infrastructure Readiness in Langkawi.
RO3: To examine the predictive relationship between Digital Participation/Learnability and Perceived Digital Infrastructure Readiness in Langkawi.

By addressing these objectives, this paper makes a major theoretical and empirical contribution: it challenges the conventional, supply-side, infrastructure-centred narrative of regional modernisation and establishes an empirical case for a people-centred paradigm of digital readiness. In managerial and policy terms, it demonstrates to regional authorities and destination managers that capital expenditure on physical connectivity must be matched by human-capacity development to ensure that digital transformation generates genuine socio-economic value.

## Literature Review

Global digitalization is taking its place and is causing drastic transformations in socio-economic spheres not only in developing countries but also in popular travel destinations (Buhalis & Amaranggana, 2013). To establish a sustainable, effective, and adaptable digital ecosystem, consideration of both technological and human capacity is essential (van Deursen & van Dijk, 2019). The review discusses the theoretical basis of the current research focusing on the Technology Readiness Index (TRI) and analyzes the literature devoted to Digital Infrastructure Readiness, Digital Literacy, Digital Access, and Digital

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Participation/Learnability (Parasuraman, 2000; van Deursen & van Dijk, 2019). It concludes with the conceptual development of the hypotheses linking these variables.

### *Theoretical Foundation: Technology Readiness Index (TRI)*

The Technology Readiness Index (TRI), originally developed by Parasuraman (2000) and later streamlined by Parasuraman and Colby (2015), conceptualises an individual's psychological propensity to embrace and utilise new technologies for home and work tasks. The framework identifies two positive drivers (optimism and innovativeness) which drive acceptance of technology, and two deterrents (discomfort and insecurity) which prevent acceptance due to fear of complexity or lack of trust in reliability and privacy (Parasuraman & Colby, 2015).

Whereas traditional TRI assessments involve direct assessment of these four mental dispositions, modern socio-technical theorists recommend that these mental dispositions be converted to concrete skills that are situational (Godoe & Johansen, 2012; Silva et al., 2022). In this study, TRI is used as a theoretical framework in contrast to being a set of measurement scales empirically. This is justified based on the theoretical relationship between TRI's psychological drivers/inhibitors and observable digital capabilities:

- Optimism and Innovativeness are embodied in Digital Participation/Learnability the willingness and cognitive flexibility of individuals to experiment with digital services, navigate unfamiliar user interfaces, and actively exploit digital platforms for socio-economic activities (Shachak et al., 2019).
- Overcoming Discomfort and Insecurity is reflected in Digital Literacy the acquisition of procedural, cognitive, and communicative skills that reduce feelings of being overwhelmed by technological complexity and mitigate fears concerning online security (Arnaud et al., 2024; van Deursen & van Dijk, 2019).
- Environmental Facilitation is captured by Digital Access representing the essential material and structural threshold required before individual technology readiness can be activated in practice (van Deursen & van Dijk, 2018).

By adapting TRI from an internal psychological scale into a people-centred operational model, this study bridges the gap between individual psychological readiness and broader regional infrastructure evaluation.

### *Conceptualising Perceived Digital Infrastructure Readiness*

It is important for digital development research to define three concepts: Objective Infrastructure Availability, Conventional Technology Readiness, and Perceived Digital Infrastructure Readiness. The latter is defined as digital readiness of organizations or individuals in terms of their predisposition (classical TRI). Infrastructure availability is an objective measure of engineering, and it is estimated based on supply-side metrics: number of kilometers of fiber optics, ratio of 4G/5G signal coverage, transmission bandwidth, and server latency (Attour & Chauvet, 2020; Nchise, 2020).

In contrast, Perceived Digital Infrastructure Readiness is conceptualised in this study as a subjective, demand-side evaluation of regional telecommunication and digital platform systems by human end-users. This involves the assessment of the readiness of the digital ecosystem in terms of its reliability, stability, speed, response rate, and maturity in enabling

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daily activities, transactions, and information seeking. Despite the potential for strong technical coverage being indicated in audits conducted from the supply side, users often perceive inadequate readiness when dealing with issues like fragmented interfaces, poor indoor signal strength, unclear transaction portals, and unacceptably high access barriers (Chinoracky et al., 2025; van Deursen & van Dijk, 2019). Consequently, measuring perceived readiness provides a realistic, human-centred metric that reflects whether digital investments deliver actionable utility to local stakeholders.

***Digital Literacy***

The core variable of this study, digital literacy, draws on the definition proposed by van Deursen and van Dijk (2019), which refers to the mental and practical capabilities to process information using digital tools; Arnaud et al. (2024) further add that its contemporary connotations have gone beyond basic operational competence, and it is a key micro-level foundation that underpins strategies for the digital revolution. It serves as a capability that enables people and organizations to become adaptive to change, think outside the box, and harness the power of technology to generate new value (Ben Ghrbeia & Alzubi, 2024). Whereas infrastructure supplies the tangible means for innovation, digital literacy sets the limits on the ability of the workforce or public to use the infrastructure safely and efficiently (Ben Ghrbeia & Alzubi, 2024; van Deursen & van Dijk, 2019). The dependency that comes out when comparing physical infrastructure and human capital is that there may be an existing strong infrastructure for the use of fast internet connectivity in any community or organization; however, the problem will arise if people do not know how to use such infrastructure effectively (Chinoracky et al., 2025; Arnaud et al., 2024).

Comparing the levels of digital literacy among different demographic groups and geographic locations demonstrates the existence of serious differences between them. In particular, contrasting the levels of digital literacy among generations proves that younger generations have higher levels of digital literacy and can easily adopt new technologies, while older generations have low adoption capabilities because of a general lack of technical skills and knowledge (Hussain & Phulpoto, 2024; Coronel & Smith, 2023). Likewise, the contrast between geographic regions reveals an important difference between urban and rural populations in terms of digital literacy. In contrast to urban people who have a good environment and therefore enjoy relatively high levels of digital literacy, rural populations face infrastructural challenges that prevent them from developing their skills (Hussain & Phulpoto, 2024; Suhaety & Mansyuri, 2026). Additionally, by contrasting the educational background, it can be seen that educated people are more capable of using technology for varied complex activities as compared to less educated people (Hussain & Phulpoto, 2024). In cases where there is no digital literacy or where it is less developed, it serves as a significant hurdle to the development and integration process. However, where digital literacy has been developed through proper training and education, it works as a means of empowering individuals, helping increase their employability and societally integrating them.

***Digital Access***

Digital Access represents the material and structural availability of hardware, software, and affordable internet connectivity (van Deursen & van Dijk, 2019). Historically, inequalities in physical access characterized the first level of the digital divide, where certain demographic or geographical areas lack access to a dependable digital infrastructure (Attour & Chauvet, 2020;

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EISSN: 0128-1666
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van Deursen & van Dijk, 2019). However, current research suggests that access is just a basic condition; having a gadget in no way guarantees an effective digital system if there are underlying social or psychological issues (Attour & Chauvet, 2020).

Based on this idea, contemporary literature makes clear differences between simply having an internet connection and having "material access" to technology (van Deursen & van Dijk, 2018). Although physical access determines whether or not one is able to connect, material access takes into consideration the variety of electronic devices that the user possesses, the ability to access auxiliary equipment (for example, another screen, a scanner, or a hard drive), and the ability to afford necessary subscriptions and maintenance costs (van Deursen & van Dijk, 2018). A comparison of the technological functionalities of these various devices reveals some of the important differences between them in terms of what they can do. For example, people using only mobile phones or tablet PCs as their means of connectivity engage in more superficial information seeking and have less ability to create content than those that use computers for advanced work (van Deursen & van Dijk, 2018).

Moreover, comparing groups based on their socio-economic status shows that there are significant structural inequalities. Rich users have access to many quality devices that ensure constant connectivity, while poor people face many interruptions in connectivity and use fewer and old devices (van Deursen & van Dijk, 2018; Hussain & Phulpoto, 2024). The comparison between different geographic regions equally reveals fundamental infrastructural disparities, since the cities have fast, efficient infrastructure and advanced digital environments, whereas the rural areas constantly face critical infrastructural challenges, such as slow connections, lack of connectivity, and expensive access options that hinder their participation in the digital world (Hussain & Phulpoto, 2024; Yusof et al., 2026; Suhaety & Mansyuri, 2026).

Demographically, access also varies significantly across age groups. Unlike younger populations, which have universal access to devices and rapid adoption of technology, older individuals encounter multiple challenges in achieving digital access, which include cost barriers, ergonomic challenges, and fear of new technologies (van Deursen & van Dijk, 2018; Coronel & Smith, 2023). Comparing investments in physical infrastructure against those in human skills is an important relationship. Just having an expansion of the physical digital network is not enough. In case the people do not have any digital skills necessary for using the internet safely, there is nothing to show for the investment (Chinoracky et al., 2025; Arnaud et al., 2024).

***Digital Participation/Learnability***

Digital Participation encompasses much more than just being connected. It is a measure of how deep, how often, and how involved individuals are in their use of the digital world, whether it be engaging in online communities, e-commerce activities, or using digital services offered by governments (van Deursen & van Dijk, 2015). A comparison between the characteristics of such an interaction in various hardware platforms highlights a great difference in the level of involvement of the user: people who use only their mobile gadgets (like smartphones and tablets) generally perform shallow searches for information and have lower capabilities when it comes to producing content, while computer users are highly involved in such activity (van Deursen & van Dijk, 2018). Furthermore, active digital engagement has come to be seen as an essential component in achieving innovation and success for services, being mainly influenced by the affordance of "interactivity" which means the ability to interact and converse actively

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with the platform and "stickiness" which means what keeps users coming back to engage more with the system (Silva et al., 2022; Mior et al., 2023).

Building on prior research, this paper centers on learnability, the core concept of technology acceptance studies. Per the 2019 definition proposed by Shachak et al., learnability refers to the ease and speed with which users can adapt to new functions and troubleshoot problems related to online services. This dimension is often measured through the ease of use in technology acceptance models. Cimbaljević et al. (2024), and Silva et al. (2022) have established that the easier the technology is to use without physical and cognitive efforts for its use, the more likely that users adopt the technology. Coronel & Smith (2023) and van Deursen & van Dijk (2018) indicate an important generation gap; younger individuals can solve the technical issues promptly, whereas older individuals face barriers due to lack of knowledge on the issue.

There is a basic transformative outcome that comes along with high digital participation. According to studies by van Deursen and van Dijk (2015), such an outcome is capable of transforming passive users into stakeholders who critically analyze their existing digital environments. Compared to digital isolated people, studies by Hussain et al. (2024) and Yusof et al. (2026) indicate that the basic foundations of such an outcome are high digital literacy and learnability. Drawing on the perspective of Arnaud et al. (2024), removing relevant barriers and nurturing in-depth engagement are necessary conditions for communities to truly gain command of and benefit from digital ecosystems.

### *Hypotheses Development*

#### *Digital Literacy and Digital Infrastructure Readiness*

Empirical evidence demonstrates that an individual's digital skills have a great effect on how technological systems are used (Ben Ghrbeia & Alzubi, 2024). In cases where individuals have high digital skills, they will be able to use complicated technologies, hence increasing their value of digital readiness (Arnaud et al., 2024; Ben Ghrbeia & Alzubi, 2024). Conversely, in situations where individuals have low digital skills, confusion will ensue, making them believe that the whole system is poor. Thus, it is hypothesized:
***H1:*** *Digital Literacy is positively associated with Perceived Digital Infrastructure Readiness.*

#### *Digital Access and Digital Infrastructure Readiness*

An individual cannot interact with or evaluate a digital network without some physical access in the beginning (van Deursen & van Dijk, 2019). High speed connectivity to the internet and devices creates a basis for interaction with the technology (Attour & Chauvet, 2020). But recent studies have shown that providing physical access by itself is not enough to close the digital divide and ensure digital transformation (Attour & Chauvet, 2020).To examine this link within the current study, it is hypothesized:
***H2:*** *Digital Access is positively associated with Perceived Digital Infrastructure Readiness.*

#### *Digital Participation/Learnability and Digital Infrastructure Readiness*

Online participation is one of the forms of digital inclusion that denotes a more mature level at which people use their digital skills to benefit from digital resources to improve socio-

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economic well-being (van Deursen & van Dijk, 2015). Communities that show high levels of digital participation and flexibility in learning possess a very good understanding of the capabilities and limitations of their digital infrastructure (Lutz, 2019). As a result of higher participation, positive views on infrastructural preparedness are boosted (van Deursen & van Dijk, 2015). Therefore, it is hypothesized:

***H3:*** *Digital Participation/Learnability is positively associated with Perceived Digital Infrastructure Readiness.*

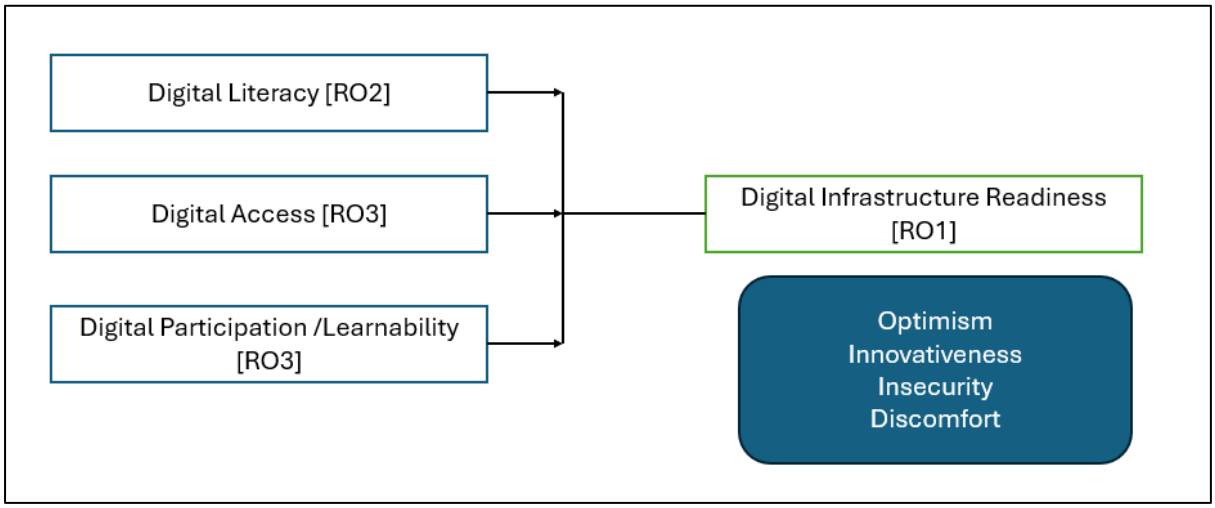


**Figure 1: Theoretical Framework**

## Research Methodology

### *Research Design and Target Population*

This study employed a quantitative, cross-sectional survey design to examine how Digital Literacy, Digital Access, and Digital Participation/Learnability predict Perceived Digital Infrastructure Readiness. The target population comprised adults (aged 18 years and above) present in Langkawi, Malaysia during the data collection period. Langkawi presents an ideal empirical setting due to its dual socio-economic character: it is an internationally acclaimed tourism hub and an island community designated as a national pilot for 5G telecommunication infrastructure and high-speed broadband deployment under the JENDELA framework.

### *Sampling Technique and Sample Characteristics*

Non-probability quota sampling technique was used in order to get various opinions from the residents, local visitors, and foreign tourists of Langkawi in important business and tourism zones of Langkawi (such as Kuah town center, Pantai Cenang, and transport terminals). The data were gathered through self-administered questionnaires on Google Forms through QR code and intercept tablets.

A total of 248 questionnaires were retrieved. After data screening for disengagement, missing data, and straight-lining, 10 non-usable questionnaires were eliminated, resulting in 238 questionnaires available for analysis (completing a usable response rate of 96.0%). Although this number is greater than the statistical power requirements for multiple linear regression analysis with three predictors (Green, 1991), it must be pointed out that the use of quota

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sampling precludes generalisability, and that the results cannot be seen as an exhaustive view of all adult populations of Langkawi.

***Research Instruments***

The survey instrument was developed by adapting items from validated, peer-reviewed measurement scales to fit the regional setting. This survey was conducted in a two-language format (English and Bahasa Malaysia). All the questions that are continuous for the core variables were measured using the 5-point Likert Scale approach. The conceptual variables were operationally defined using four core multi-item constructs; Digital Infrastructure Readiness (Dependent Variable) is measured using 14 items adapted from QoS framework in telecommunications. Items used here measure perceptions of network speed, signal presence, reliability and maturity of the platform. On the other hand, Digital Access (Independent Variable) was operationally defined using four (4) items measuring hardware possession, capability and data price. Then, Digital Literacy (Independent Variable) was operationally defined using four (4) items measuring the skills of the users as well as the use of software and information available through internet. Finally, Digital Participation / Learnability (Independent Variable) which measured using five (5) items measuring active participation in transactions within online digital platforms.

***Result and Findings***

To ensure instrument accuracy and psychometric reliability as the basis for further inferential 304odelling, the internal consistency of reliability analysis was done on each multi-item scale by means of Cronbach's alpha (α). Consistent with standard psychometric criteria, values of alpha at or above 0.60 had to be attained in order to indicate acceptable functioning of the scales. The structural indices of the dependent and three independent variables are presented in Table 1.

**Table 1: Results of Correlation Analysis, Reliability Analysis**

| No | Variables | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1 | Digital Access | (0.73) | | | |
| 2 | Digital Literacy | .600** | (0.76) | | |
| 3 | Digital Participation/Learnability | .559** | .451** | (0.86) | |
| 4 | Digital Infrastructure Readiness | .502** | .429** | .277** | (.83) |

The statistical indicators confirm that all measurement scales meet the generally accepted psychometric criteria of $\alpha \geq 0.60$ for exploratory model research. Particularly, Digital Participation/Learnability (IV) and the Digital Infrastructure Readiness (DV) measurement show high scores of $\alpha = 0.86$ and $\alpha = 0.83$, respectively, proving that the instrument is reliable for further inferential evaluation.

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In the correlation, the correlation study confirmed that the relationship between the independent variables and dependent variable. The correlation tests indicate that all three independent variables are positively and significantly correlated with perceived Digital Infrastructure Readiness at the $p < .01$ alpha tier. The relationship strengths range across the following values: Digital Access demonstrates a strong positive and statistically significant relationship with Perceived Digital Infrastructure Readiness ($r = .502$, $p < .01$). This suggests that greater availability of digital technologies and connectivity resources implies higher levels of preparedness for digital infrastructure among citizens.

There is a moderate and statistically significant correlation between Digital Literacy and Perceived Digital Infrastructure Readiness ($r = .429$, $p < .01$). The implication of the correlation is that those who are well digitally literate perceive the digital infrastructure as more ready.

Digital Participation/Learnability shows a weak-to-moderate positive and statistically significant relationship with Perceived Digital Infrastructure Readiness ($r = .277$, $p < .01$). Although the relationship is weaker than those of Digital Access and Digital Literacy, higher participation and learnability are still associated with more favourable perceptions of digital infrastructure readiness.

***Regression Analysis***

For testing hypothesis H1, H2, and H3 simultaneously, a multivariate multiple linear regression analysis was performed. This statistical analysis determined the ability of the independent variables to predict the Digital Infrastructure Readiness perception. The results of the analysis are presented in Table 2.

**Table 2: Results of Regression Analysis**

| Model Variables | Standardized Coefficients Beta |
|---|---|
| **Digital Access** | 0.205 |
| **Digital Literacy** | 0.328* |
| **Digital Participation** | 0.439** |
| **R Square** | 0.866 |
| **Adjusted R Square** | 0.861 |
| **R Square Change** | 0.866 |
| **F Change** | 161.740 |
| **Sig. F Change** | 0.000 |

**Notes: ** significance at the .01 level; * significance at the .05 level**

Regression analysis reveals strong structural prediction ability, with 86.1% of the total variation in digital infrastructure readiness explained by the model ($R^2 = 0.866$, Adjusted $R^2 = 0.861$, $p < 0.001$). Hypotheses tests reveal the following:

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Digital Literacy is a highly significant positive predictor of infrastructure readiness ($\beta$ = .328, $p$ = .004). Users who are able to evaluate and effectively use digital information resources perceive higher structural assessments of digital environment. The variable Digital Access has failed to prove its ability to influence the model directly in the multivariate analysis ($\beta$ = .205, $p$ = .056). This shows that providing physical hardware or connectivity links acts merely as a passive baseline, it does not contribute significantly to perception without addressing human capability gaps. Digital Participation was found to be the most important direct predictor of the whole model ($\beta$ = .439, $p$ < .001). Active involvement in transactional digital environments creates positive perception about the region infrastructure development.

**Table 3: Hypothesis Result**

| No | Hypothesis | Result |
|---|---|---|
| 1 | ***H1:*** *Digital Literacy has a significant positive influence on Perceived Digital Infrastructure Readiness.* | **H1 is supported.** |
| 2 | ***H2:*** *Digital Access has a significant positive influence on Perceived Digital Infrastructure Readiness.* | **H2 is not supported** |
| 3 | ***H3:*** *Digital Participation/Learnability has a significant positive influence on Perceived Digital Infrastructure Readiness.* | **H3 is supported.** |

## Discussion

The study investigated how Digital Literacy, Digital Access, and Digital Participation/Learnability predict the readiness of digital infrastructure. In light of the Theory of Technology Readiness Index (Parasuraman, 2000), the outcomes provide an empirical validation for a crucial hypothesis of technology readiness that is people-based: the readiness of digital infrastructure largely depends on one's ability and participation in using it rather than on material access to it.

Despite the fact that access can be considered an indispensable element of participation in the digital world, the results of the research show that access alone is not enough in order to form positive perception about readiness of infrastructure. Instead, it seems that what matters is efficient usage of digital technologies and the ability to actively participate in the digital world. More specifically, Digital Participation / Learnability turned out to be the most important predictor of Perceived Digital Infrastructure Readiness among significant predictors, followed by Digital Literacy. Digital Access was not statistically significant at all.

The evidence presented above further supports the case for looking at digital readiness beyond the mere presence of network infrastructure, devices, and connectivity. Modern conceptualizations of the digital divide tend to separate access to digital technology and the capacity to make good use of digital technology. As argued by Van Deursen and van Dijk (2018, 2019), the gap in access has been increasingly replaced with disparities in digital skills, usage, and outcomes. The evidence presented above extends this discussion to the realm of regional

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digital infrastructure, suggesting that people will perceive such infrastructure in a more positive light when they have the capacity to use its services effectively.

***The Decisive Role of Digital Literacy (H1 Supported)***

The results confirm H1 that hypothesized that Digital Literacy would have a positive impact on Perceived Digital Infrastructure Readiness. Digital Literacy had a significant positive impact ($\beta = .328$, $p = .004$). These results imply that the individuals who were more digitally literate were more likely to perceive the infrastructure around them more favorably. It may be concluded from these results that the perception of infrastructure readiness depends not only on the technical nature of the infrastructure but also on individuals' digital literacy.

The finding is in line with what van Deursen, and van Dijk (2015) posited concerning how the digital inequalities in the modern times are mainly based on the difference in informational and operational abilities rather than merely on access. Likewise, Arnaud et al. (2024) and Ben Ghrbeia & Alzubi (2024) point out digital literacy as a key micro-skill which helps people to utilize digital transformation successfully. Indeed, it means that the development of technological infrastructure will be of little help in cases where users lack necessary skills to operate platforms and perform any other tasks.

In addition, the study finding can be viewed from the perspective of the broader concept known as the second-level digital divide. As the first level digital divide is centered around whether people have access to technological tools, the second level digital divide is about the effectiveness of using these tools by people. This distinction becomes particularly important in case of Langkawi. Even though the region offers high-speed internet and digital tools, it does not mean that they will be perceived by local population and tourists as efficient ones. People who are better in terms of digital literacy skills will definitely feel more comfortable while using various applications, services, and information tools.

The present finding is also consistent with the local evidence presented by Sharif et al. (2021), where they emphasize the significance of ICT knowledge and skills needed for the local community in Langkawi to gain the benefit of digital technologies. These findings suggest that the value of infrastructure is partly achieved via user capacity. It can then be concluded that digital infrastructure is an enabling resource, and digital literacy is the measure of one's ability to make use of such resource.

The Technology Readiness Index (TRI) framework offers an interesting theoretical perspective to understand this connection. In his work on this issue, Parasuraman (2000) argued that people have different levels of general readiness for adopting technology due to enabling and disabling psychological perspectives. Even though this study did not include a direct measurement of any of the four dimensions of TRI, digital literacy may help users cope better with technology and lower the challenges related to technology discomfort and insecurity. In such a way, digital literacy may lead to the creation of a positive perception of the technology context around a person who is able to interact with technology better. Therefore, since no individual dimensions of TRI were measured in the current research, this view should be seen as a theoretical one.

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***The Nuance of Digital Access: Baseline Prerequisite vs. Direct Predictor (H2 Not Supported)***

In contrast, H2 was not supported because Digital Access did not have a statistically significant direct influence on Perceived Digital Infrastructure Readiness in the regression model ($\beta$ = .205, p = .056). This is an important finding because it indicates that the mere availability of devices, connectivity, or affordable access may not independently determine how users evaluate the readiness of a regional digital ecosystem when other human-capability variables are considered simultaneously.

This does not mean that digital access is less important. Digital access will still be the key requisite because it is not possible for an individual to use digital platforms without being adequately connected with a suitable gadget. What it means is that once the basic access is acquired, the perception of digital readiness will largely be determined by what an individual can do with that access. This observation conforms completely to the theory of digital divide at second and third levels (van Deursen & van Dijk, 2018, 2019). Connectivity becomes the primary requirement as there can be no interaction without the requisite access. However, once a certain threshold of network coverage has been crossed (achieved through JENDELA and 5G programs in different sectors of Langkawi), the access becomes irrelevant in determining the evaluation by users. The differences in perception of readiness will be based on the competency of the individual to use that access.

The insignificant direct effect is also in line with a larger shift that has occurred in research on the digital divide. The earlier research paid significant attention to the connection status while the latter research pays much attention to the issues of usage and performance. As an example, Chikomba et al. (2023) and Pukdeewut (2024) show that the digital divide in the contemporary context occurs on many different levels and cannot be resolved merely by connecting people physically.

The Langkawi context may provide a useful explanation for this result. As an established tourism destination with substantial digital infrastructure development, respondents may already have relatively widespread access to connectivity and digital devices. If access has become relatively common, differences in physical availability may have less explanatory power than differences in users' competencies and patterns of engagement. In such circumstances, the critical question changes from "Can individuals access digital technology?" to "Can individuals use the available technology effectively and meaningfully?"

Accordingly, the result does not imply that policymakers should reduce infrastructure investment. Instead, it suggests that infrastructure investment should be complemented by initiatives that strengthen user capability and facilitate meaningful usage. Expanding coverage and improving connectivity remain important, but their social and economic value may be greater when users possess the necessary skills, confidence, and opportunities to utilise those resources.

***The Primacy of Digital Participation and Learnability (H3 Supported)***

H3 was supported, with Digital Participation/Learnability emerging as the most significant predictor of Perceived Digital Infrastructure Readiness was Digital Participation/Learnability ($\beta$ = .439, p < .001). This result is especially relevant since it means that active engagement

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EISSN: 0128-1666
Volume 11 Issue 44 (September 2026) PP. 296-315
with digital products and the capacity to learn about technology are highly correlated with the perception of the digital environment.

This result supports the argument that meaningful digital readiness is developed through usage rather than access alone. Users who regularly engage in e-commerce, online transactions, digital public services, communication platforms, or other online activities gain repeated experience with the strengths and limitations of the digital ecosystem. As a result, they become well-equipped to assess the appropriateness and adequacy of digital services for their needs.

The finding is consistent with van Deursen and van Dijk (2015), who conceptualise digital participation as a higher level of digital inclusion in which individuals move beyond basic connectivity toward active use of digital resources. It also corresponds with the material-access perspective of van Deursen and van Dijk (2018), which suggests that the quality and intensity of technology use influence the benefits individuals derive from digital environments. In this sense, an individual who is technically connected but rarely interacts with digital systems may have a very different perception of readiness compared with a user who regularly performs online transactions and engages with multiple digital platforms.

Learnability provides an additional explanation for the strength of this relationship. Users are more likely to engage repeatedly with digital systems when interfaces are easy to understand and when new functions can be learned with relatively little effort. This interpretation is compatible with the broader technology-acceptance literature. Venkatesh et al. (2003), for example, emphasise the importance of effort expectancy in technology adoption, while Shachak et al. (2019) conceptualise learnability as the ease and speed with which individuals become competent in using technological systems. When users can adapt quickly to new services, they are likely to experience lower levels of operational difficulty and greater confidence in the digital ecosystem.

***Perceived vs. Objective Infrastructure Readiness: A Cautious Interpretation***

A vital interpretive distinction must be maintained regarding the finding that readiness "extends beyond physical connectivity." The data gathered in this study reflect perceived infrastructure readiness, which measures subjective evaluations, satisfaction, and perceived utility. It does not measure objective telecommunication engineering parameters, such as physical throughput, signal-to-noise ratio, or server downtime. Thus, claiming that human capabilities shape perceived readiness does not imply that physical fiber cables or cellular towers are dispensable; rather, it proves that physical cables alone do not guarantee a positively evaluated digital ecosystem if the human components of literacy and participation are neglected.

TRI offers a useful interpretive perspective for this finding. Parasuraman's (2000) framework proposes that favourable orientations toward technology can encourage adoption, while discomfort and insecurity may inhibit it. Active participation and repeated learning experiences may provide users with greater familiarity with digital environments, which may in turn reduce perceived complexity and uncertainty. However, because the individual TRI dimensions were not directly measured in the present study, this interpretation should be regarded as a theoretical explanation rather than an empirically tested mediating mechanism.

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The stronger effect of Digital Participation/Learnability compared with Digital Literacy also provides a deeper insight into digital readiness. Digital literacy represents what users are capable of doing, whereas participation reflects the extent to which those capabilities are actually translated into behaviour. An individual may possess adequate digital skills but still make limited use of available digital services. In contrast, active participation requires users to apply their skills in real situations, interact continuously with technological systems, and adapt when platforms or services change. This may explain why Digital Participation/Learnability demonstrated the strongest relationship with Perceived Digital Infrastructure Readiness.

Taken together, the findings point toward a distinction between availability, capability, and engagement. Digital Access represents the availability of technological resources; Digital Literacy reflects the capability to use those resources; and Digital Participation/Learnability captures the extent to which users actively engage with and adapt to digital environments. The results suggest that capability and engagement may be more influential than availability alone in shaping perceptions of regional digital infrastructure readiness.

This distinction provides a more nuanced interpretation of people-first digitalisation. The findings do not suggest that infrastructure is unimportant; rather, they demonstrate that infrastructure becomes meaningful when individuals possess the capabilities and opportunities required to use it. Physical investment can establish connectivity, but meaningful digital transformation requires users who are able to understand, navigate, evaluate, and continuously engage with digital systems.

This interpretation is consistent with Uren and Edwards (2023), who emphasise the importance of organisational and human readiness in digital transformation, and with Chinoracky et al. (2025), who highlight the role of education and human-capital readiness in supporting broader digital transformation. Thus, regional digital development may be better conceptualised as a socio-technical process in which infrastructure and human capabilities operate together rather than as independent alternatives.

### *Theoretical Implications*

The theoretical contributions of this study are twofold. First, the study reframes the Technology Readiness Index (TRI) into a socio-technical paradigm. Rather than confining TRI to internal psychological personality traits, this study applies its core logic to observable socio-technical dimensions namely digital access, digital literacy, and learnable participation demonstrating that the transition from psychological readiness to functional infrastructure evaluation is mediated through individual skills and platform adaptability. Second, the findings advance a people-centred understanding of digital readiness that directly challenges supply-side technocentric models equating infrastructure maturity solely with hardware deployment. By demonstrating that Digital Participation/Learnability and Digital Literacy supersede physical access in predicting perceived digital infrastructure readiness, this study establishes that regional digital maturity must be theorised as an interactive socio-technical outcome rather than merely an engineering milestone.

### *Practical Implications*

This research provides several implications for policymakers, digital-service providers, tourism entities, and regional planners in Langkawi. The first implication is that alongside

increased investments into connectivity there must be a set of measures implemented to ensure increased digital literacy. Training programs could include skills such as usage of digital government services, making secure online payments, assessing online information, and using digital payment systems.

Secondly, since Digital Participation/Learnability proved to be the most significant predictor, more emphasis needs to be placed on the usability and learnability of digital tools. The platforms available for use by residents as well as tourists need to ensure that there is no unnecessary complexity involved in their design and that they have intuitive interfaces along with multiple language options and guidance.

Thirdly, the approach to digital development must center on increasing opportunities for productive uses instead of simply assessing the success of their initiatives based on metrics like connectivity and ownership of devices. This can be accomplished through efforts that ensure integration of digital services into people's everyday lives through travel, tourism information, local business, governance, health care, and community services.

Finally, the results imply that the notion of infrastructure and human capacity should be seen as complementary parts of regional digital development. In such a case, there is no point in presenting investment as choosing one over the other. An adequate digital environment presupposes both good technological infrastructure and individuals who have appropriate skills and confidence in its usage.

## Conclusion

Building a mature, resilient regional digital ecosystem cannot be achieved through hardware deployment alone. While physical digital access provides a necessary foundational baseline, expanding connectivity without concurrently cultivating user skills and participatory interfaces leads to underutilised technological capacity. This study demonstrates that Perceived Digital Infrastructure Readiness in Langkawi is overwhelmingly predicted by Digital Participation/Learnability and Digital Literacy, while Digital Access exerts no statistically significant independent effect in the multivariate model. Ultimately, regional digital development must transition from a technocentric infrastructure paradigm toward an inclusive, people-centred strategy where human competence and intuitive digital participation sit at the core of technological policy.

**Acknowledgements:** The authors would like to express their sincere gratitude to MCMC Kedah State Office, Langkawi Development Authority (LADA), and Pejabat Laut Wilayah Utara for providing the necessary resources and support throughout the course of this research. Special appreciation is extended to colleagues and peers who contributed valuable insights and constructive feedback, which greatly enhanced the quality of this paper.

**Funding Statement:** This research received financial support from Malaysian Communications and Multimedia Commission (MCMC) under Digital Society Research Grant. The funding body had no role in the design of the study, data collection, analysis, interpretation of results, or the decision to publish this manuscript.

**Conflict of Interest Statement:** The authors declare that there is no conflict of interest regarding the publication of this paper. All authors have contributed to this work and approved the final version of the manuscript for submission to the International Journal of Modern Education (IJMOE).

**Ethics Statement:** This study involved interviews with adult participants and did not require formal institutional ethics approval in accordance with the researchers' institutional guidelines. Participation was voluntary, informed consent was obtained from all participants before the interviews, and participants were informed of their right to withdraw at any stage. To protect confidentiality, identifying information was removed from the interview transcripts and pseudonyms were used in reporting the findings.

**Author Contribution Statement:** All authors contributed significantly to the development of this manuscript. Nor Azimah Kamruddin was responsible for the conceptualization, methodology, and overall supervision of the study. Norhayati Mohamad Hussain handled data collection, analysis, and interpretation of results. Mutiiah Mohamad and and Fadli Fizari contributed to the literature review, drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 11 Issue 44 (September 2026) PP. 296-315

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