

Towards a contextual digital competence framework for assessing citizens' digital proficiency

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ABSTRACT

This study aims to develop a contextualized digital competence (DC) framework for assessing citizens' digital proficiency and addressing DC disparities among citizens of Sarawak, Malaysia. A qualitative research approach, which comprises contextual analysis, stakeholder engagement, and content validation and refinement, was used to achieve the study objective. Findings from the contextual analysis highlighted significant gaps in digital infrastructure and literacy, particularly among rural communities. A total of 18 experts were engaged in this study. The result of the stakeholder engagement provided insights into the specific digital skill needs within Sarawak's unique socioeconomic landscape, emphasizing the need for foundational competencies such as device recognition, online safety, and data management. The content validation helps to produce the refined Sarawak DC assessment framework (SDCAF) for assessing the DC of citizens. This framework holds promise as a foundation for future digital literacy initiatives in Sarawak, promoting inclusive digital transformation in line with the state's digital economy strategy. This study concluded that SDCAF is a comprehensive and relevant tool for measuring citizen's DC. The SDCAF is a model for creating targeted, accessible digital literacy programs that bridge the urban-rural digital skill divide and empower all citizens to participate in Sarawak's digital society.

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1. INTRODUCTION

The pace of digital transformation worldwide is changing how individuals and societies interact with technology. This change appears not yet uniform, especially among regions with distinct socioeconomic challenges like Sarawak, Malaysia [1]. While urban areas in many Malaysian States are advancing digital literacy and infrastructure, rural areas still lag in digital competence (DC) [2]. The growing disparity in digital skills and access is exacerbating socioeconomic inequalities between urban and rural communities, contributing to the phenomenon of the digital divide [3]–[5].

Empirical evidence from past literature shows that in today's interconnected world, DC is essential for navigating the rapidly evolving technology ecosystem [6]. DC enables individuals to access services, interact with others, participate in the global economy, and engage with governance [7]. Citizens with strong digital skills can leverage online resources for education, career advancement, and even civic participation, which can help address broader socioeconomic challenges [8], [9].

However, despite the Sarawak government's efforts to close the digital divide gap, many citizens remain digitally less savvy. A lack of accessible, high-quality information and communication technology (ICT) infrastructure limits opportunities for rural populations to develop the needed digital skills to participate in an increasingly digital society [10], [11]. The limited DC of these communities makes them more vulnerable to cyber risks such as identity theft, online scams, and the spread of misinformation [12]. Moreover, the difficulties in interacting with critical services such as healthcare, e-government, education, and financial services further entrench the existing socioeconomic challenges of rural dwellers [12].

Research shows that teachers and students in rural and indigenous communities exhibited low levels of ICT knowledge and awareness, which hindered the integration of digital tools into learning environments [13], [14]. Similarly, Bala *et al.* [15] and Mustafa *et al.* [16] found that low education levels, limited access to ICT resources, language barriers, and inadequate training in remote areas in Malaysia contributed to limited ICT usage. These findings support global evidence that the issue of the digital divide is often rooted in physical and intellectual limitations to technology access [6], [17]–[19].

Addressing these issues necessitates targeted interventions designed to aid the digital proficiency of Sarawakians. These initiatives must focus on teaching basic digital literacy and equipping citizens with advanced digital skills to enhance their employability and capacity to engage effectively in the digital ecosystem [20]. A digitally competent population is critical to realizing the Sarawak government's long-term vision of inclusive digital transformation, as articulated in its Sarawak Digital Economy Strategy (SDES) 2018-2022 and the post-COVID development strategy (PCDS) 2030 [21], [22]. Sarawak Digital Economy Blueprint 2030, which emphasized the need to empower citizens with the digital skills necessary to thrive in a high-tech economy, aligns with the Malaysia digital agenda (MyDIGITAL) and aligns with the UNESCO Sustainable Development Goals (SDGs 4, 9, 10, and 11), significantly bridging the digital inequality gap (SDG4.4.2).

Evidence from various global initiatives supports the notion that improving digital literacy in underserved regions can have a transformative socioeconomic impact [6], [7], [23]. For instance, the study of Lynn *et al.* [7] highlights that increasing digital skills among rural populations could result in greater social inclusion, reduced unemployment, and better access to essential services such as e-governance and telemedicine. This finding resonates with the Sarawak context, where a comprehensive approach to digital literacy could help alleviate long-standing socioeconomic inequalities and promote sustainable rural development. Hence, this study investigates the DC phenomenon in Sarawak, which has received little empirical focus to date.

The Sarawak government's PCDS 2030 envisions a digital society by 2030 where all citizens, irrespective of location, can benefit from digital technology. However, for this vision to be realized, it is crucial to address the issue of persistent DC deficiencies. The inadequacy of digitally competent citizens not only limits economic opportunities for the citizens but also hinders their ability to participate in the democratic and social processes increasingly mediated through digital platforms [24].

Therefore, it is critical to assess the DC levels of Sarawakians to understand how DC relates to their participatory behaviors in the Sarawak digital society and the extent of the digital skill divide between the rural and urban populations. Such an assessment will provide invaluable insights for developing targeted policies and initiatives to bridge possible DC gaps and ensure that all citizens are equipped to contribute to and benefit from Sarawak's digital future.

In line with this, this study presents a conceptual framework (Sarawak Digital Competence Assessment Framework (SDCAF)) tailored to the socioeconomic context of Sarawak. The framework can be used to evaluate the digital proficiency level and participatory behaviors of citizens, and it will help identify the specific areas where interventions are needed to reduce the digital skill divide. Moreover, the framework will assess the current DC deficiencies and propose solutions to ensure that rural Sarawakians are not left behind as the state drives towards digital inclusivity by 2030.

This study introduces the SDCAF, a contextualized DC framework specifically designed to assess citizens' digital proficiency within Sarawak's unique socioeconomic and infrastructural landscape. Unlike existing generic frameworks, SDCAF is tailored to address the digital divide by incorporating insights from contextual analysis and stakeholder engagement, ensuring its relevance to both urban and rural communities. Additionally, the study employs a qualitative validation process involving expert input, making SDCAF a robust and adaptable model for guiding targeted digital literacy initiatives and inclusive digital transformation in alignment with Sarawak's Digital Economy Strategy

2. LITERATURE REVIEW

DC has emerged as a key enabler of participation in modern digital societies [9], [25]. Defined broadly as the skills, knowledge, and attitudes needed to use digital technologies effectively, DC encompasses various domains, including information literacy, communication, content creation, safety, and

problem-solving [26]. The uneven distribution of digital competencies, often termed the “digital divide,” is influenced by factors such as socioeconomic status, access to technology, education, and geographical location [3], [27]–[29]. These disparities are somehow pronounced in regions like Sarawak due to distinct socioeconomic and infrastructural challenges.

The European Digital Competence Framework for Citizens (DigComp) has been the most widely adopted model for assessing DC globally [26]. This framework fundamentally outlines five core areas of competence: information, communication, content-creation, safety, and problem-solving. These areas provide an understanding of the essential skills needed for full participation in digital society. However, the DigComp framework, while helpful, is not universally applicable without context-specific consideration and adaptation to different settings [8]. Developing regions like Sarawak Malaysia have their own context-specific socioeconomic and infrastructural challenges that are influenced by several factors and require a tailored approach to assist in effective targeted policies and initiatives that can bridge this competency gap and ensure that all citizens are equipped to contribute to and benefit from Sarawak’s digital future [30], [31].

While many other global frameworks also provide valuable insights into digital skills development for DC, most models often focus on more developed contexts and neglect the unique challenges of marginalized groups, such as those in rural settings. Table 1 explores some of these frameworks, identifies their strengths and weaknesses, and maps how they align or diverge from the needs of Sarawak communities. In particular, the discussion addresses how these gaps create an opportunity to develop a framework that addresses rural digital disparity, as the present study aims.

Numerous studies have examined the factors contributing to DC disparities [29], [32]–[35] highlighted the importance of access to digital infrastructure as a key determinant of DC. His work showed that rural populations often face more significant challenges in acquiring the necessary skills due to limited access to high-speed Internet and digital tools. This aspect is particularly relevant to Sarawak, where rural areas continue to lag behind urban centers in terms of both infrastructure and educational opportunities related to digital technologies [12], [36]. Official statistics from the Department of Statistics Malaysia show that the rural-urban digital divide has narrowed but persists, with 2024 internet access at 98.8% in urban households versus 90.3% in rural areas [37]. This gap indicates that rural communities still face lower digital infrastructure access despite national improvements. Similarly, Pusat Internet initiatives improved communication, learning, literacy, entrepreneurship, and information access, but implementation challenges limited their full impact [38]. These findings indicate that addressing the rural digital divide requires not only infrastructure expansion but also digital-skills training and user support to promote safe and meaningful online participation.

A study conducted in rural Sarawak, Malaysia, examined digital access and literacy and found that, despite the availability and use of digital infrastructure, substantial digital-skills gaps persisted because of limited knowledge and digital competence [12]. Such limitations are especially significant for marginalized rural groups, as poor connectivity and low digital capability restrict access to education, services, and economic opportunities. Digital literacy also plays a protective role: Malaysian evidence shows that critical evaluation skills reduce scam susceptibility [39]. Research has also pointed to the growing importance of safety and security as a competence for managing risks, protecting data, and ensuring user well-being [40]. Globally, there is a rise in privacy and data protection concerns [41]. A study by Załoga and Bryczek-Wróbel [42] highlighted the possible challenges that might be faced by populations with low digital security awareness, particularly in regions with growing internet penetration but limited digital education. This is a key concern for Sarawak, where digital adoption is accelerating, but without the corresponding increase in digital literacy, many users remain susceptible to cyber threats [11], [43].

Despite the significant progress in understanding digital disparities, existing research has predominantly focused on infrastructural challenges and often overlooked the broader socioeconomic and cultural dimensions that influence DC. Meanwhile, there is a dearth of research specifically addressing the development of comprehensive DC framework that account for Sarawak’s unique socioeconomic landscape. This study fills these gaps by proposing a tailored DC framework that integrates regional challenges and targets developing essential digital skills for participation in a digital ecosystem.

As DC becomes vital to modern life, various frameworks have emerged to conceptualize and guide the development of essential digital skills, each offering insights relevant to the present conceptual framework. These frameworks inform the design of the SDCAF, ensuring it is not only aligned with global standards but also tailored to the unique needs of the region.

DigComp-European Commission [17]: The European Union’s DigComp framework is foundational in digital literacy and includes competencies like information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Its strength lies in its comprehensive structure, covering a wide range of essential digital skills, which can serve as a baseline for DC. However, while DigComp effectively outlines digital literacy goals, its complexity and overlapping competencies make it complex to use as a measurement tool. It also lacks specificity in device and media recognition—a critical area for rural Sarawakians where essential technology awareness remains low. SDCAF addresses this by

incorporating device and software operations at an introductory level, bridging the knowledge gap in fundamental hardware and software usage to support entry-level digital engagement.

Digital literacy global framework-UNESCO-[44]: UNESCO's framework emphasizes functional skills such as device and software operations, information and data literacy and safety. This focus on basic functional skills is valuable for Sarawak, where information and communication technology or ICT infrastructure is still developing, especially in rural areas. The framework's limitation, however, lies in its insufficient emphasis on digital productivity and advanced skills needed for dynamic digital participation. SDCAF builds on UNESCO's approach by adding advanced competencies in digital interaction management and productivity, preparing Sarawakians to engage more fully in economic and social activities as ICT infrastructure improves.

Joint information systems committee (JISC) digital capability framework: known for its focus on professional digital capabilities, the JISC framework incorporates skills like ICT proficiency, media and data literacy, digital communication, collaboration, innovation, personal development, digital identity, and well-being [45]. Its strength is supporting higher-order skills and innovation, making it suitable for contexts where digital infrastructure and literacy levels are already advanced. However, JISC's framework applies less to rural populations with limited foundational skills. SDCAF adapts JISC's focus on digital proficiency and creativity by emphasizing communication and collaboration skills while grounding them in functional contexts, such as managing information and data across commonly used interfaces. This ensures that rural Sarawakians build core competencies progressively and are equipped to transition to more creative and productive technology uses.

Integrative framework of consumers' digital competences [46]: this framework provides a consumer-oriented approach, focusing on consumption, interaction, and protection competencies. It highlights self-responsibility and cybersecurity awareness, critical in protecting users from cyber threats as digital penetration increases. However, it falls short of addressing emerging digital technologies and tools crucial for advancing economic opportunities. SDCAF expands on this by integrating competencies in device management, digital safety, and security and focusing on emerging technologies. This alignment ensures that citizens use digital tools safely and leverage new technologies to enhance socioeconomic participation.

Strengthening SDCAF with localized insights: while the existing frameworks provide valuable insights, they are often generalized for urbanized, high-resource settings. SDCAF is designed to address the unique challenges in Sarawak by emphasizing device and media recognition, software and interface operation, and information and data management as foundational competencies. In addition, the framework incorporates safety and security measures critical for rural populations, who may be new to digital environments and, hence, more vulnerable to cyber threats. Therefore, SDCAF's integration of foundational and advanced digital skills that span from basic literacy to productivity and innovation positions it as an essential tool to foster an inclusive digital society, bridge urban-rural disparities, and align with Sarawak's digital economy goals.

These frameworks collectively offer diverse approaches to understanding and enhancing digital competence, each tailored to distinct audiences and purposes, from education and employment to consumer interactions and organizational digital transformation. Table 1 summarizes the strengths and limitations of the reviewed frameworks.

Table 1. Summary of strengths and limitations of four DC framework

Framework	Strengths	Limitations
DigComp	Comprehensive and widely recognized in Europe Structured around well-defined competence areas Adaptable across various educational and occupational settings	Primarily developed for the European context, limiting global adoption Limited emphasis on rapid technological advancements Complex and overlapping competencies.
Digital literacy global framework	Addresses digital divide and inclusivity in developing countries Universally adaptable across different global contexts Promotes critical understanding and safe use	Broad and universal focus may lack detailed guidance for advanced users Generalized framework, less specific to certain digital environments
Digital capability framework	Focused on organizational digital transformation	Primarily targeted at organizations, limiting personal applicability Limited focus on specific consumer or personal digital skills
Integrative framework of consumers' digital competences	Comprehensive, covering multiple competencies for professional use Practical for digital consumers, focusing on transaction and risk management Addresses online safety, credibility, and transaction management	Limited to consumer digital interactions, lacks broader digital skills May not be applicable in professional or educational contexts

3. METHOD

The multifaceted nature of digital competence requires a subtle and holistic approach to its development by considering the unique cultural, social, and demographic characteristics of the intended domain [47]. This study adopts a comprehensive, multi-phased qualitative approach to develop and validate the SDCAF to address the digital competence disparities in Sarawak, particularly between urban and rural populations. The approach ensures that the framework is empirically grounded, contextually relevant, and aligned with local socioeconomic needs. The methodology follows these sequential stages as depicted diagrammatically in Figure 1.

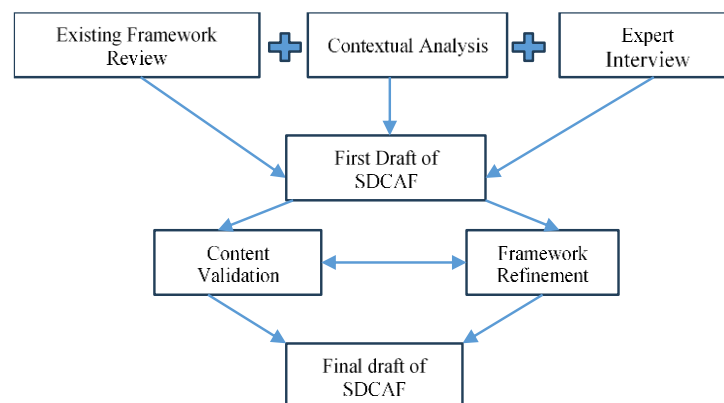


Figure 1. Flow of research methodology

3.1. Contextual analysis

This phase involves an extensive contextual analysis to understand the digital competence landscape in Sarawak. This includes reviewing current digital competence levels, socioeconomic factors affecting digital access, adoption, and existing digital infrastructure. Data was gathered from government reports, regional digital literacy studies, and prior research on digital competence frameworks relevant to rural-urban disparities, such as DigComp, UNESCO's digital literacy global framework, and local studies by organizations like Malaysian Communications and Multimedia Commission and Sarawak Digital Economy Corporation. The findings from this analysis inform which digital competencies are essential for Sarawak and reveal specific challenges-such as limited access to devices and internet infrastructure, especially in rural areas. The implementation of SDCAF will facilitate bridging the digital divide (in terms of skills) in Sarawak and foster inclusive digital participation across all sectors.

3.2. Stakeholder engagement

Since digital competence needs can vary across demographics and sectors, engaging key stakeholders was essential to ensure that SDCAF is practical and widely applicable. Stakeholders included government representatives, educators, industrial professionals, and community representatives. Engagement activities comprised focus groups, personal interviews, and consultations aimed at gathering insights into the specific digital skill requirements for different sectors, identifying barriers to digital engagement, and assessing the socio-cultural factors affecting digital adoption as it relates to DC [48]. This phase also explores stakeholder expectations, potential application areas of the framework, and recommendations for integrating digital skills within Sarawak's unique socioeconomic landscape. Stakeholder engagement provided valuable insights into the diverse digital competence needs across various demographics in Sarawak. Stakeholders generally agreed that a digital competence framework tailored to Sarawak's needs could facilitate equitable access to digital resources, provided that it includes clear, practical guidance suitable for various literacy levels.

A preliminary draft of the SDCAF structure was formulated based on insights obtained from contextual analysis and stakeholder feedback. The foundational competencies were aligned with key global frameworks, including DigComp and the JISC Digital Capability Framework, to ensure comprehensiveness and comparability with established standards. However, the SDCAF was specifically tailored to address identified gaps, such as device and media recognition, digital safety, and basic software operation skills for rural communities. The framework was structured into core competencies, each encompassing specific skills relevant to Sarawak's needs, including device usage, data management, communication, security, and emerging technologies.

A purposive sampling method was used to select the experts based on experience in the field/domain being studied, professional background, research publications, or recognition/contribution in the field of Sarawak's digital agenda. Face-to-face and online engagement was conducted with 18 experts/stakeholders [48]. Questions and responses related to the research objective were obtained, providing a clear direction for developing the proposed framework. This study connected the experts' heuristics, known field principles, and the experts' knowledge to design the SDCAF components.

After the saturation point of data collection, the next step was transcribing and listening to the recorded data. This was done to compress the data and digest it to make more sense by ensuring that all significant data from the experts were captured in the analysis to enhance the confidence and trustworthiness of the study's findings [49]–[52]. A thematic analysis was used to analyze the data obtained from the experts. As described in Table 2, to draw valuable insights that contribute to the broader research objectives, rigorous evaluations were done to ensure that the information gathered from the experts was valid, reliable, and relevant to the research context. A summary of this process is provided in Table 2. This table ensures that each step in the evaluation process directly contributes to refining and validating SDCAF. This method enhanced the validity and trustworthiness of the findings by ensuring that all significant expert input was systematically captured and aligned with the research objectives [49], [50], [52].

Table 2. Steps in the evaluation of expert interview

Step	Description	Result/outcome (based on SDCAF thematic analysis)
Step 1: topic-oriented transcription	The researcher transcribes the interview recording while focusing on the topics discussed, ensuring key themes are accurately captured.	Key topics such as digital literacy, infrastructure challenges, workforce upskilling, and digital inclusion were accurately documented for further analysis.
Step 2: paraphrasing and data cleaning	The researcher simplifies and clarifies the transcribed text, removing unnecessary or redundant information.	Refined expert responses into concise statements, eliminating repetitive and unrelated details while maintaining meaningful insights.
Step 3: thematic overview	The main themes that emerged from the interview data were identified and summarized.	Major themes identified: Digital competence disparities (urban vs rural), digital skills integration in education, cybersecurity awareness, and industry adoption of digital tools.
Step 4: thematic comparison between interviews	Identified themes were compared across different interviews to find commonalities and differences.	Experts agreed on key challenges (limited internet access, lack of structured training) but differed on policy implementation strategies and the role of private sector involvement.
Step 5: conceptualization	The researcher develops concepts based on the themes identified, refining them into coherent ideas.	Core SDCAF components were refined, focusing on digital productivity, cybersecurity, and emerging technologies as essential digital skills.
Step 6: integration into theoretical discourses	The researcher relates the conceptualized ideas to existing frameworks within the DC field.	SDCAF was aligned with existing digital competence models (DigComp, MyDigital Blueprint) while incorporating contextual elements specific to Sarawak.

3.3. Content validation and framework refinement

Content validation was conducted through expert review. Two rounds of validation were conducted, first with the group of the initial experts, to understand their agreement or disagreement with the use of words (language adjustment) and component (structure) of the framework. Content analysis was done to ascertain the presence of certain words, themes, or concepts [53]. Another group of independent experts was consulted based on their knowledge of digital competence, education, and specific localized context knowledge. To confirm the pertinence of the identified DC component areas and to further understand other critical contextual elements in Sarawak, each expert was requested to evaluate every framework component based on its relevance, clarity, and alignment with the local context [54]. The researcher further reviewed these experts' qualitative feedback on each component. This review led to more robust framework adjustments and the development of the final draft of the conceptual framework SDCAF.

As illustrated in Figure 1, the final phase produced a refined SDCAF based on feedback and data gathered. Adjustments were made to better align competencies with the observed local context, particularly in simplifying language and ensuring the framework resonates with the local context. Digital safety and privacy competencies were added based on feedback indicating the need for more explicit guidance. The last consultation was conducted with the experts to validate the refined framework and ensure SDCAF robustness and relevance to Sarawak's broader digital strategy.

The final version of the SDCAF was then compared with established DC frameworks, as presented in Table 3, to confirm that it aligns with established measures while adapting to the local context. It is hoped

that when implemented, SDCAF will facilitate bridging the digital divide in Sarawak and foster inclusive digital participation across all sectors. SDCAF is a holistic, comprehensive, and exhaustive tool for assessing citizens' DC proficiency.

Table 3. Comparison of SDCAF with four global frameworks

DigComp (European Union, 2016)	Digital literacy global framework (UNESCO, 2018)	JISC digital capability framework	Integrative framework of consumers' digital competences	SDCAF
Information and data literacy	Device and software operations	Digital proficiency and productivity (functional skills)	Information competences	Device (hardware) and media recognition
Communication and Collaboration	Information and data literacy	Information, data, and media literacies (critical use)	Interaction competences	Software and interface operation
Digital content creation	Communication and collaboration	Digital creation, problem-solving, and innovation (creative production)	Consumption competences	Information and data management
Safety	Safety	Digital communication, collaboration, and participation (participation)	Protection competences	Safety and security
Problem-solving	Problem-solving	Digital learning and development (development)	Self-responsibility competences	Digital interaction management
	Career-related competence	Digital identity and well-being (self-actualizing)	Innovations competences	Digital productivity
				Emerging technologies

4. RESULTS AND DISCUSSION

4.1. Level of citizens' participation in the digital society

The level of participation in a digital society refers to how actively and extensively individuals and communities engage with digital technologies and platforms [55]. A digital society is characterized by the widespread use of digital devices, internet connectivity, and online services, enabling people to communicate, share information, conduct transactions, access services, and participate in various online activities [56]. Experts had divided opinions regarding the level of citizen participation in the Sarawak digital society and the factors responsible. One expert assert that the level of participation of Sarawakians in the digital economy is shallow. He also stated a glaring disparity in terms of locations and industries. Also, most urban settlements participate more and embrace digital society than rural areas in Sarawak. According to the expert in the interview session, Sarawakian participation in the digital society is at level one out of nine, whereby most citizens are seen as mere users who are trained/coerced to use the digital tool without even knowing its usefulness. To achieve level nine participation, the government needs to dream of the project with the ground users, developing technology for the people, with a deep understanding of local knowledge and involvement of the people/users, rather than the government-initiated/enforced/imported technology on the citizen [57]. Technology should be developed with the involvement of the local community [58].

Regarding digital awareness, the expert believes there is an increasing positive movement. Many citizens know the prevalence and availability of digital tools, such as Sarawak Pay. Nevertheless, willingness to use and acceptability is still backward. Another expert believed that at the initial stage of the launch of the Sarawak digital agenda in 2017 and 2018, when the Sarawak government decided to embark on a digital economy, citizen participation was relatively lukewarm. However, the impact of the COVID-19 pandemic has accelerated the adoption of digital tools. COVID-19 has changed citizens' attitudes and perceptions. Before COVID, people wondered why they should talk or attend class online when they could meet the person physically, and people who initially did not want to learn or did not know how to use specific digital tools started getting to know, understand, use, and participate more in the digital society. So, it is not about age, gender, or race influencing citizen participation but attitude. The expert believes that Sarawakian's digital attitude has changed positively over the years, mainly due to the impact of COVID-19. These findings align with those of study by Barrutia and Echebarria [59], who conducted a similar study on public managers in Spain.

Talking about Sarawakian's young ages (younger generation), the expert presumes that most have the necessary competencies (basic level) to use the web and internet tools, but not responsibly or ethically. They could be termed user-interface natives (native UI). For citizens exposed to and using daily digital tools, their competency will be high or improve over time. It is a matter of exposure and training that decides individual competency. The expert, therefore, links citizens' digital competence to the usage level of digital tools, which affects their participation. On the contrary, one of the experts believes that digital inequality in

age and location exists in Sarawak because the younger ones are exposed. Familiarity with and using digital tools bring about essential competencies in the younger generations. However, inequality exists in terms of location because of access. There is also a disparity in industries; government offices enforce the use of digital tools more than others, and inequalities in social and economic status. Previous empirical studies have examined how socioeconomic status, geographical location, age, and gender affect individual digital competence [60]–[63]. However, their findings remain inconsistent, and no clear consensus has been established regarding these relationships.

Other experts believe that Sarawakian participation and involvement in the digital society might be hard to describe since no previous confirmatory study has been conducted. However, on a scale of 1–10, it would be around levels 7 to 8. There is no impact study done yet to give facts and figures on citizen participation in Sarawak's digital economy. The Sarawak Development Institute did a digital readiness study but faulty/low sampling, and the findings could not be used as much. The expert also believes there is a significant disparity in gender and location regarding the DC in Sarawak. This aligns with a similar finding by Grande-De-Prado *et al.* [64].

Despite the disparity in opinions from the experts, this study can infer that the level of digital participation is on a positive increase in Sarawak. Technology adoption and integration into daily lives are well accepted and, on the rise, even though the digital divide still exists in locations and industries. Citizens with higher digital literacy/competence are likelier to engage with and benefit from digital tools and platforms. It is good that as the government's digital investment and budget increase, digital awareness and presence improve, and the citizen attitude toward digital participation also increases positively. However, it is yet to ascertain the relationship between the citizens' DC and participation, as there are several other factors (internet access, access to devices, trust and security, government policies, cultural, social, and economic factors) that can influence the level of participation in a digital society. Also, no holistic and inclusive past study has examined and measured citizens' DC proficiency in Sarawak. As being digitally competent is not something we are born with, education and other factors play a crucial role in shaping citizens' digital competence, which is needed to leverage their participation in the digital society.

In conclusion, a high level of participation in a digital society like Sarawak can lead to numerous benefits, such as improved access to information, enhanced communication and collaboration, increased economic opportunities, and greater civic engagement. However, it is essential to address barriers to digital inclusion to ensure everyone can participate and benefit from the opportunities the digital world offers. According to one of the experts, "If we wish to empower citizens digitally, we should focus on their goals for digital usage, the areas in which digital activity is socially meaningful and contributes directly to the development of meaning and identity." Digital competence can be of great value for social participation and inclusion.

4.2. The components of digital competence suitable for Sarawak.

Developing a digital competence framework for Sarawak requires addressing the region's unique socioeconomic and geographical characteristics. According to one of the experts, the existing DC frameworks are not done with the involvement of the local community, so it is irrelevant to the community's needs. The aspect of indigenous knowledge management should be enshrined in a digital framework. Also, the popular DigComp framework is not participatory in its design [17], and even if it is, it involves mainly a European audience/subject within a particular age/job/professional qualification/industry, which means only a subset of the knowledge was represented which has nothing to do with Sarawak. Therefore, the existing framework cannot be benchmarked to Sarawak. Using European standards and knowledge/framework to measure Sarawakian digital competence is erroneous because of the standard's biases. He also iterates that the direct usage of the European DigComp framework to determine Sarawakian's DC level can be likened to an enslavement mechanism, undermining the indigenous knowledge of the people. The Sarawak people are known for their strong values and cultural heritage [65], [66], which should be captured and reflected in the development of their digital society [67].

Also, the complexity in the existing competence framework is biased towards digital natives and will write off many elders and older people because they mostly do not have the inspiration to use the computer. Language or English literacy is another barrier in the existing framework. DC framework should be simplified and easy enough for everyone-general citizens-regardless of age, occupation, educational level, or location. The existing framework, especially DigComp, assumes citizens already know how to use the digital tool. It is not fundamental enough and has already segregated a level/category of citizens. For example, the frameworks have not examined basic/lower skills such as how to move the mouse, power on, configure appliances, transaction skills, and fill forms online. Some frameworks reviewed did not differentiate digital knowledge, skills, and attitudes for each competent area. One of the experts' said skills are primarily for specific things or actions; knowledge makes you understand why. Therefore, DC should be

separated into skills, knowledge, and attitude. He continues by saying that digital attitudes, values, and norms are part of the culture and guide individuals in digital space. Therefore, culture, religion, values, and ethics should be coated under digital attitude and enshrined in digital competence framework development.

Our framework, SDCAF, tests knowledge, skills, and attitudes of essential concepts of the information society (hardware, software, and connections) and the digital culture and ethics of the citizen, and this includes critical digital practices aimed at efficiency, ergonomics, the environment, and respect for the rights and work of other people. SDCAF focuses on how well to use technology in everyday activity and participation in the digital society, not so much on how to create technology. The first level of competence in SDCAF is device and media recognition. This is more specific for lower-income societies like Sarawak, which must identify this basic level. There is a need to keep monitoring which new technological innovations might have implications for these identified competencies. As a result, the framework proposed here will need a revision process that considers the impacts of new and upcoming technological developments and new social practices and adoptions.

The contextual analysis phase revealed several factors that contribute to digital competence disparities in Sarawak, particularly between rural and urban populations, and the expectation of a DC framework. Based on the responses from the experts, this study found that the digital divide exists in terms of skills. Aside from the limited access to high-speed Internet and digital infrastructure in rural areas, the digital skill divide was prevalent in Sarawak. This critical factor affected digital participation, particularly among marginalized groups. According to a 2022 study by the Malaysian Communications and Multimedia Commission, only about 51% of Sarawak's rural residents reported regular internet use, compared to nearly 84% of urban residents [39]. This gap is compounded by limited digital literacy and infrastructure in rural areas, with many communities lacking essential digital skills for modern employment, education, and e-government services. Additionally, a 2021 survey by the Sarawak State Government found that only 40% of rural Sarawak residents felt confident using essential digital tools like email and online forms [22], highlighting a critical need for targeted digital skills training to bridge this divide.

Therefore, in a technologically advanced society, we must insist that everyone has the same right to computer literacy that they have always had to traditional literacy (reading and writing). Classical and digital literacy grow more intertwined in a culture where technology permeates every aspect of life. Some literacy theorists, e.g., [68]–[70], have already proposed redefining “literacy” to include reading/writing and digital behaviors. Like traditional literacy, digital literacy provides all citizens a channel to interact with their community, shape their world, and influence the social order. One way for seniors to keep some control over their lives in this time of growing unpredictability is to improve their digital literacy. Thus, increasing involvement in the digital society is possible when the DC framework is contextualized and aligned with local activities and the culture of the people.

Cultural or societal factors such as language, educational systems, cultural values, indigenous knowledge, and socioeconomic factors can influence the development of digital competence frameworks by shaping the competencies considered necessary, the policy priorities emphasized, and the attitudes and behaviors valued. Understanding these factors is vital for developing effective digital competence frameworks that are relevant and meaningful in different contexts. The benefits of incorporating cultural or societal factors into digital competence frameworks are that they efficiently promote inclusivity, relevance, equity, and global perspective. This can support the development of digital competencies among citizens in different contexts and promote digital technologies for learning, work, leisure, and participation in society. Digital competence is an essential concept in Sarawak, as it is in many other parts of the world. Individuals must possess the knowledge, skills, and attitudes required to use digital technologies effectively in modern society.

One of this study's significant findings was that a socioeconomic and educational barrier exists to citizens' DC proficiency. Another major finding of this study was that digital inequality mirrors, to a significant extent, the offline inequality related to socioeconomic resources/status of citizens. The inequalities in many digital societies happen because available digital resources/technology only serve the already connected—hence the rural-urban digital skill disparity experience in Sarawak. Socioeconomic and educational inequalities in Sarawak closely mirror digital inequality, as they create barriers that prevent individuals from accessing and utilizing digital technologies effectively. People with lower incomes often cannot afford digital devices, reliable internet access, or digital education, limiting their ability to engage in online opportunities for learning, work, and social connection. Educational disparities compound this lack of access; individuals with limited schooling may lack foundational digital skills, making navigating an increasingly digital world harder. This gap reflects how socioeconomic and educational disparities perpetuate digital divides as access to technology and digital skills increasingly determine economic and social mobility. Findings show that wealthier or more educated individuals are more likely to possess advanced digital skills and use the Internet for educational and professional advancement. In contrast, those from disadvantaged backgrounds often remain excluded.

These findings underscored the peculiarity of the issue to Sarawak's local context and hence the need for a contextual development framework that addresses foundational skills like device usage, media literacy, incorporating local languages (e.g., Iban, Bidayuh, and Malay) and online safety, particularly for populations with limited exposure to digital environments. SDCAF addresses a critical gap in Sarawak's digital ecosystem by providing a structured approach to understanding, measuring, and building foundational digital skills, particularly for rural populations.

4.3. Framework development

Based on the above-discussed result, the critical area of DC for this study is highlighted and provided in Table 3, which compares it to the global frameworks discussed earlier. SDCAF is developed based on citizens' skills that are necessary/required to participate in a digital society. Table 4 provides a detailed explanation of the components of the framework.

In contrast to established frameworks like DigComp and the JISC digital capability framework, SDCAF emphasizes foundational competencies such as device recognition and basic software operations, which are essential in rural areas with limited digital exposure. This focus aligns with findings from previous studies [6], which suggest that foundational skills are crucial for enabling participation in digital environments, especially among populations with limited formal education. Moreover, SDCAF's emphasis on digital safety and security resonates with the identified need to protect users from cyber threats in regions with limited digital literacy [42]. The identified competencies are both relevant and critical, given the vulnerability of less digitally literate populations to online risks.

Table 4. Proposed SDCAF components

	Components	Description
1	Device (hardware) and media recognition	Awareness of the discrete physical component of an information technology system or infrastructure. Identify/recognize basic digital hardware and its function, and understand digital symbols, ports, and their connections. E.g., input devices, processing devices, output devices, memory (storage) devices, network hub, webcam, keyboard, mouse, and tablet
2	Software and interface operation	This is the understanding of the actions that a digital object can do. Understanding different interface appearance and functionality allows users to interact with digital tools in many ways. This includes the understanding of display icons, installation, and interface design (graphical user interface, command-line interface, and menu-driven interface)
3	Information and data management	Browse, identify, locate, retrieve, store, evaluate, manage, and organize information
4	Digital interaction management	Link with others, participate in online networks and have constructive interactions. Netiquette. Communicate, collaborate, and interact digitally
5	Safety and security	Protect devices, personal data, health and well-being, and the environment. Behave ethically and responsibly, and be aware of legal frames
6	Digital productivity	The use of digital tools to carry out tasks effectively, productively, and with attention to quality. Work fluently across different software/apps and services to achieve daily tasks. For example, digital content creation, using word processors, databases, spreadsheets, desktop publishers, graphics programs, web page creators, podcast development apps, emails, buying and selling, purchases, payment, and solving problems through digital means
7	Emerging technologies	Knowledge and competency related to artificial intelligence (AI), internet of things (IoT), datafication, cloud computing, virtual reality (VR), augmented reality (AR), robotization, and datafication

5. CONCLUSION

The results from this study provide insights into the need for contextual development of a digital competency framework to address the digital skill divide. The digital competence disparities across Sarawak's urban and rural populations depict a growing concern for a more concerted effort to curb this menace. Each phase of the framework development, from contextual analysis to refinement, ensured SDCAF's relevance, usability, and adaptability within Sarawak's socioeconomic landscape.

In conclusion, the SDCAF represents a vital step toward addressing the digital competence disparities in Sarawak, offering a localized, practical approach to building foundational digital skills. The framework's emphasis on foundational competencies, informed by empirical evidence and stakeholder engagement, positions it as a key tool for fostering inclusive digital participation across Sarawak. As competencies are constantly changing due to emerging trends and technologies, we aim to use this SDCAF as a starting point to develop a comprehensive and dynamic artifact for DC measurement in Sarawak that aligns with the government's digital development agenda. It is recommended that this framework be regularly updated to fit the new digital age and accommodate technological advancements and changing social

practices. In terms of policy and practical implication of the study findings, the study suggests the need for targeted training programs in rural areas that focus on foundational competencies, such as device handling and online safety, before progressing to more advanced skills, and also the urgent need for investment in digital infrastructure, particularly in underserved rural regions, to enable equitable access to digital resources and training opportunities. The successful implementation of the framework will underscore the importance of tailoring digital competence initiatives to the unique needs of local contexts rather than relying solely on generalized global frameworks. This contextual adaptation is crucial for bridging digital divides and fostering inclusivity. While the study provides valuable insights, several limitations warrant further research. The need for the implementation of the framework to measure the actual DC proficiency of citizens and statistical analysis for reliability testing such as exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and internal consistency should be done by administering the framework to sample groups and to validate the framework's applicability across broader demographics. Future efforts should focus on scaling up the framework's implementation and integrating it into Sarawak's digital economy initiatives, ensuring that all Sarawakians have the skills necessary to thrive in an increasingly digital world.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nterpretation

R : **R**esources

D : **D**ata Curation

O : **O**riginal Draft

E : **E**diting

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included/interviewed in this study.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [AVO]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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