

ICT Education for Indigenous Communities in Malaysia: A Conceptual Review on Needs, Challenges and Opportunities

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ABSTRAK

Information and Communication Technology (ICT) education has become an essential component of sustainable development, particularly in ensuring equitable and inclusive access to quality learning opportunities for marginalised communities. This conceptual review examines the necessity of ICT education among the Indigenous Orang Asli communities in Malaysia by analysing how digital literacy, technological exposure, and cultural adaptation intersect with broader goals of community empowerment. While earlier debates centred on whether Indigenous learners require ICT integration, current developments highlight its growing importance for accessing global knowledge, enhancing socio-economic opportunities, and preserving cultural heritage in digital formats. Findings from the literature suggest that ICT education functions not only as a tool for academic learning but also as a pathway for Indigenous empowerment, participation, and self-determination within contemporary society. ICT exposure enables Orang Asli communities to bridge the digital divide, strengthen cultural resilience, and adapt to the demands of an increasingly technology-driven economy. This review further identifies key factors supporting ICT inclusion, including access, culturally responsive pedagogies, and community-driven digital initiatives. Ultimately, ICT education must be positioned as a fundamental need rather than an optional resource, ensuring that Orang Asli learners are equipped with the competencies required to thrive while safeguarding their cultural identity. This paper proposes that aligning Indigenous cultural values with ICT integration is vital for achieving meaningful digital participation and fostering long-term community sustainability

Keywords: ICT, ICT education, Indigenous People, digital divide, empowerment community,

INTRODUCTION

The evolution of globalization and the development of the digital economy have reshaped the social and epistemological structures of contemporary societies, including indigenous communities such as the Orang Asli in Malaysia. The sophistication of Information and Communication Technology (ICT) has not only accelerated the flow of information, but also created new forms of interaction between traditional knowledge systems and modern technologies. In the context of global development, ICT is recognized as a transformative driver that changes the way societies interact, manage resources, and participate in digital ecosystems (Revathi & Aithal, 2019). The world's dependence on technology has now made digital literacy a critical dimension of economic and social participation, including for communities that have long operated within a nature-based knowledge framework. In addition to its use in communication and daily life, ICT has become a component that strengthens the capacity of organizations and social systems. The integration of ICT enables more efficient administrative processes, data-driven learning, and innovation across various sectors such as education, health, community economics, and natural resource management (Deja et al., 2021). Ahmed et al. (2021) asserted that technology now influences almost all aspects of modern life, from learning practices and marketing strategies to forms of social interaction and ecological monitoring. Therefore, the widening digital divide is not just a technological issue, but also affects opportunities for social mobility and the ability of communities to participate in the flow of progress.

While the discourse on ICT typically focuses on innovation and productivity, the challenge of inclusivity remains a significant issue, especially for indigenous communities. For Orang Asli, issues such as limited infrastructure, lack of technological equipment, and the absence of a learning environment that supports the use of ICT often hinder meaningful digital participation. Past studies have shown that access to ICT does not necessarily lead to effective use if it is not supported by culturally responsive pedagogy, community support, and understanding of local values and ways of life (Abdullah & Derus, 2020; Mahmud et al., 2022). This suggests that technological inclusivity requires a holistic approach that combines physical (access), pedagogical (curriculum appropriateness), and sociocultural (community acceptance) dimensions. Accordingly, the increasing importance of ICT in a global society demands an in-depth analysis of the critical factors that contribute to ICT inclusivity in Orang Asli communities. ICT integration cannot rely solely on the provision of infrastructure, but must take into account the compatibility of pedagogy with cultural identity, traditional learning modes, and community aspirations. Community-based technology initiatives such as digital learning centers, cultural mapping projects, and traditional e-documentation platforms also play an important role in empowering communities themselves and preserving their identities in the digital space. Thus, this section emphasizes the need to understand how access, culturally responsive pedagogy, and community engagement can ensure that ICTs function as tools of empowerment rather than epistemological invasions of Indigenous knowledge systems.

Within this context, the Indigenous Orang Asli of Peninsular Malaysia represent one of the country's most culturally distinct minority groups, characterised by rich heritage traditions, deep ecological knowledge and sustainable community practices (Masron et al., 2013). While their cultural identity remains resilient, the digital era presents both opportunities and challenges for the preservation, revitalisation and transmission of Indigenous knowledge. Integrating ICT education into Orang Asli communities offers the potential to bridge gaps in access to global knowledge, support culturally relevant learning, strengthen community development and foster empowerment through digital participation. At the same time, it requires careful attention to issues of cultural sensitivity, digital equity and community-driven approaches to ensure that technology adoption does not undermine Indigenous identity. Guided by principles of culturally responsive pedagogy, community engagement and inclusive education, this conceptual review explores how ICT education can contribute to both technological literacy and cultural resilience among Orang Asli learners. By examining the intersections between Indigenous worldviews and digital practices, this paper positions ICT education not merely as a tool for academic enhancement but as a foundational component for sustainable development, cultural preservation and meaningful participation in the digital age.

Research Objective

Identify critical factors that support ICT inclusivity, including access, culturally responsive pedagogy, and community-based technology initiatives.

LITERATURE REVIEW

Information and Communication Technology (ICT) is increasingly becoming a key component of educational development, shaping the way individuals connect, learn and participate in society. While many communities naturally adopt digital tools as part of their daily lives, the meaning of ICT for Indigenous groups such as the Orang Asli must be understood through their lived experiences and cultural contexts. The literature often reminds us that Indigenous knowledge systems are not static, but rather adaptive and capable of evolving alongside modern tools when engagement is respectful and meaningful (Battiste, 2013). ICT is widely recognised as an enabler of educational opportunities, social mobility and access to global knowledge (Selwyn, 2016). Studies of Indigenous communities around the world demonstrate how digital technologies can support cultural preservation through storytelling platforms, digital archives and community-led documentation (Dyson, 2012; McMahon, 2014; Ozdemir, 2022). These examples challenge the assumption that technology threatens Indigenous identity. Instead, they demonstrate that ICT can be a space where tradition and innovation coexist.

In Malaysia, Orang Asli communities continue to face structural challenges that shape their digital participation. Limited infrastructure, unstable internet access and minimal exposure to devices can restrict their engagement with ICT (JAKOA, 2019; Ismail & Azizan, 2020). However, these barriers are not just technical; they intersect with cultural, linguistic and socioeconomic factors (Russo et al., 2014). Many Orang Asli families express

concerns about cultural erosion or question the immediate relevance of ICT to their traditional livelihoods (Nicholas et al, 2010). Such concerns are often rooted in generational experiences with marginalization or isolation. Despite these challenges, this literature highlights the strong potential for ICT education to empower Orang Asli learners. When ICT is introduced in a culturally responsive and community-based way, it can strengthen children's capacity to navigate both the traditional and modern worlds (Kral, 2012). ICT supported learning can also increase self-confidence, provide exposure to a wider range of knowledge and reduce educational disparities between rural Indigenous students and the mainstream population (Saha, 2023). At the same time, scholars emphasize that meaningful ICT implementation cannot focus on access alone. Digital inclusion must also address digital skills, relevance, safety and the cultural legitimacy of technology in Indigenous spaces (Warschauer, 2003; Carretero et al., 2017). Studies consistently show that when Indigenous voices, values and aspirations shape the design of ICT initiatives, the outcomes are more sustainable and empowering (Mignone & Henley, 2009). However, a notable gap in the literature is the limited attention paid to the human experience of ICT learning among Indigenous communities. While quantitative indicators such as device ownership and connectivity are often reported, fewer studies explore the emotional, cultural and social dimensions that influence ICT engagement. Understanding this human perspective informs the hopes, fears, motivations and daily negotiations among Indigenous people. This is essential to designing ICT education that resonates with Indigenous students and supports their long-term empowerment.

In addition to issues of access and infrastructure, contemporary debates in the literature also emphasize the importance of culturally responsive pedagogy in ensuring that ICT has a positive impact on Indigenous communities. According to Gay (2018), culturally responsive learning not only recognizes student identity, but also integrates traditional epistemologies and ways of learning into modern curriculum design. In the Indigenous context, several scholars have stated that the introduction of ICT needs to be integrated with community knowledge such as narrative-based learning, environmental connections, and collectivist values (Kral & Schwab, 2012). This approach is important to avoid what Freire (2009) referred to as "education of oppression," in which technology is introduced without considering community agency and voice. Culturally sensitive use of ICT also enables Indigenous students to build digital identities that do not marginalize their heritage. Studies in Australia and Canada have shown that digital platforms designed with communities can foster cultural pride, facilitate intergenerational learning, and encourage higher education engagement (Welch & Saltmarsh, 2023; McMahon, 2020). In Malaysia, several pilot projects such as community-based digital storytelling initiatives and village-based technology workshops have shown that Orang Asli students are more likely to explore ICT when technology is contextualized in their daily experiences. For example, documenting forest knowledge, customs, or native languages through digital recordings (Bow & Hepworth, 2019). These findings reinforce the view that ICT empowerment is not just about imparting technical skills, but building meaningful connections between technology and culture.

However, the literature also reminds us that the integration of ICT in Indigenous communities requires serious attention to issues of ethics, autonomy and data sovereignty. The principle of Indigenous data sovereignty states that data relating to Indigenous communities, including digital materials, learning records and cultural content, should be controlled, owned and managed by the Indigenous community itself (Kukutai & Taylor, 2016). Without such protections, technology can become a new medium for power inequality, knowledge exploitation or misuse of digital identities. In addition, the use of algorithms, educational applications and commercial platforms often do not take into account cultural, language and contextual biases, thus potentially perpetuating stereotypes against Indigenous students (Benjamin, 2019). In global studies, many educators emphasize that successful ICT programs in Indigenous communities are those that involve long-term collaboration, consultation with community leaders and continuous adaptation based on user feedback (Resta & Laferrière, 2015). In Malaysia, although education policies increasingly emphasize digitalization, implementation at the Orang Asli community level requires a different approach, including culturally sensitive teacher training, content development in native languages, and collaboration between schools, NGOs, and social institutions (Adam, 2022; Jamaludin et al., 2025). Combining these perspectives, the literature suggests that understanding students' human experiences such as a sense of belonging, cultural dignity, and social aspirations are critical factors in ensuring that technology truly contributes to meaningful learning. Therefore, future studies need to explore the everyday realities of ICT use among Orang Asli students, including motivational dynamics, family relationships, hopes for the future, and how they negotiate identities in digital and traditional spaces simultaneously.

METHODOLOGY

Narrative synthesis was used to review the existing literature on ICT education among Indigenous Peoples. Relevant studies were identified through electronic databases such as Google Scholar, Proquest, EBSCO, Scopus & Web of Science. Hasbie, Assim, Taasim & Mahdi, (2023) emphasized that using keywords will facilitate the search for relevant articles. Among the keywords used for the search were “ICT”, “Orang Asli”, “digital inclusion”, “telecentre”, “ICT literacy”, and “Orang Asli education”. Selected sources included peer-reviewed journal articles, conference proceedings, and grey literature reports focused on urban and rural Orang Asli settings. Content and thematic analysis were used in the study (Cetinkaya, 2025; Humble & Mozalius, 2022).

Table 1 Inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Time line	2010 - 2025	< 2010
Publication type	Research articles (empirical data)	Book series, review articles, proceedings paper, paid articles, published before 2010
Language	English	Non english

Table 1 show that criteria for the inclusion and exclusion article journal which involve in this study. A limitation of this study is selection bias; for example, the eligibility criteria involve papers that were written in English and there was exclusion of articles in languages other than English. Article chronology is from 2010 to 2025, and works published before 2010 are omitted. Moreover, these publications are selected by researchers from databases with empirical data and book series, review articles, progress papers and paid papers are not considered as primary source.

FINDING AND DISCUSSION

From the literature highlights, there are several themes that have been identified,

1. The potential of ICT as a catalyst for educational and social empowerment

Shows that ICT is not just a technological tool, but functions as a catalyst for empowerment that enables Orang Asli students to access global learning resources, increase digital literacy, and bridge the educational gap between rural and mainstream communities. Selwyn (2016) emphasizes that students who gain digital exposure have the opportunity to develop a broader understanding of the world, while Ozdemir (2022) prove that the use of technology increases academic achievement and student confidence in digital-based classrooms. In addition, ICT also plays a significant role in strengthening culture through digital archives, language documentation, and community-driven storytelling platforms (Dyson, 2012; McMahon, 2014). This is where ICT offers a dynamic space where traditional knowledge can be transformed without sacrificing cultural identity. Thus, the potential of ICT in Orang Asli communities is not only instrumental, but is in line with long-term efforts to build agency, autonomy, and critical awareness among the younger generation.

2. Structural challenges and socio-cultural dynamics affecting digital participation

Despite the significant potential of ICT, the digital divide in Orang Asli communities continues to be affected by structural barriers such as lack of internet coverage, inadequate basic infrastructure, and low device access (JAKOA, 2019; Russo et al., 2014). Socio-economic factors such as poverty, geographical location, and the cost of maintaining devices exacerbate these inequalities. However, the literature also emphasizes that barriers are not purely technical; they include cultural concerns about the risk of identity erosion, the irrelevance of technology to traditional livelihoods, and a history of marginalization that influence the level of ICT adoption in the community (Nicholas, 2010). This situation shows that Orang Asli digital participation is a complex phenomenon influenced by power structures, collective memory, and socio-historical realities, not simply a

matter of connectivity. Therefore, a holistic approach is needed to understand how technical and cultural barriers interact to determine the level of digital engagement of students.

3. The importance of culturally responsive pedagogy and community-based ICT design

A key consensus in the literature is that the effectiveness of ICT does not depend on the technology itself, but on how it is designed and implemented in the cultural context. Gay (2018) asserts that culturally responsive pedagogy helps to strengthen learners' identities, while Kral and Schwab (2015) emphasize that Indigenous epistemologies such as narrative-based learning, spiritual connections to nature, and collective practices need to be integrated into digital content. Successful ICT programs in Indigenous communities around the world typically involve consultation with village leaders, community co-design, and ongoing adaptation based on local user experiences (Mignone & Henley, 2009; Resta & Laferrière, 2015). This suggests that ICT initiatives cannot operate in a top-down manner but should value the worldview, values, and aspirations of the community. Such an approach not only increases community acceptance of technology, but also ensures that programs are more inclusive, sustainable, and aligned with the real needs of Indigenous learners.

4. Research gaps, ethical dimensions and the future of digital sovereignty

Although a growing body of research discusses digital access and literacy, the literature still shows a lack of research on the human dimension, namely the emotional experiences, motivations, fears and processes of Indigenous learners negotiating their digital identities. Warschauer (2003) emphasizes that digital inclusion needs to emphasize the social dimension and not just technical access. At the same time, ethical issues such as algorithmic bias, commercial technological dominance and the risk of exploitation of cultural knowledge demand more serious attention. The principle of Indigenous data sovereignty asserts that communities must have full rights to their digital data, including cultural content, historical records and community narratives (Kukutai & Taylor, 2016). Benjamin (2019) also warns that technology can reinforce inequalities if developed without sensitivity to cultural and racial contexts. Therefore, the future research agenda needs to focus on building ICT models that are not only inclusive and culturally sensitive, but also ethical, based on community sovereignty and respectful of Indigenous digital autonomy.

From all the themes, this study shows that ICT has the potential to transform the educational experience for Indigenous students, but only when approached with sensitivity to cultural and community realities. Access alone is not enough as meaningful ICT learning requires the integration of cultural values, community engagement and student identity. The human experience of Indigenous students must be at the heart of ICT initiatives. Many Indigenous students navigate complex tensions between tradition and modernity. Some may worry that digital tools may erode cultural identity, while others may see ICT as a pathway to wider opportunities. Findings have shown that when technology is framed as a tool for preserving culture such as documenting traditional stories, environmental knowledge or community heritage students perceive it as empowering rather than threatening (Dyson, 2012; McMahon, 2014). Another important point of discussion is the role of schools and teachers. Educators working with Indigenous students need support in integrating ICT in ways that respect Indigenous epistemologies. Without culturally relevant pedagogical strategies, ICT risks being perceived as irrelevant or externally imposed. Community engagement is equally important, with ICT adoption being strongest when parents, elders and local leaders participate in co-designing ICT programs. Finally, sustainable ICT education requires addressing structural barriers such as connectivity, device availability and digital training. These barriers disproportionately affect remote communities, reinforcing digital inequalities. Addressing them is important not only for educational equity but also for national development goals.

Indigenous communities are increasingly adopting information and communication technologies (ICT) to address challenges and promote the preservation and development of their cultures. In fact, Indigenous communities are increasingly adopting ICT for educational purposes (Luaran et al., 2016), cultural information (Hasbie et al., 2023), socio-economic and socio-cultural purposes of Orang Asli in Peninsular Malaysia (Walid, 2021). In addition, ICT can play an important role in providing access to formal and informal education, healthcare, new economic opportunities and preserving their traditional knowledge with the emergence of technology (Kent & Sepcht, 2023; Kohsaka & Rogel, 2021). With the emergence of information and communication technologies (ICT), it plays an important role in empowering Orang Asli communities in several

ways and alternatives. Among them are access to information, economic opportunities, preserving cultural heritage, communication development as well as advocacy and representation. Through access to information, ICT education can provide Orang Asli communities with the tools and knowledge to access the vast amount of information available online (Clothey, 2014; Bala & Tan, 2021; Kamsin, 2023). This directly enables Orang Asli communities to continue to access and obtain information, learn about their rights, access educational resources and connect with the wider world. In addition, by acquiring ICT skills, Orang Asli individuals can take advantage of various economic opportunities. Orang Asli can start their businesses to a global audience and take advantage of e-commerce platforms, thus increasing the economic well-being of Orang Asli (Hadi et al., 2024).

In the preservation of cultural heritage, ICT education can enable Orang Asli communities to document, preserve and share their rich and diverse cultural heritage. Among these is the use of digital media, websites and social media platforms so that Orang Asli communities can showcase their customs, traditions and traditional knowledge, fostering pride and cultural awareness among the Orang Asli community itself and with the wider world (Khong et al., 2025). Next is community development through ICT education that can equip Orang Asli with skills to enhance community development. Indigenous people can use technology and communication, better collaboration and coordination within their communities, facilitating social and economic initiatives such as healthcare delivery, education and sustainable development projects. Next, advocacy and representation, Indigenous people generally face unique challenges and issues that require advocacy and representation. With ICT education, we can raise awareness among Indigenous people about their rights, mobilize support and connect with other Indigenous communities around the world, fostering unity and collective action among them. In addition, Indigenous communities often have deep knowledge and connections to their lands. ICT can support their efforts in environmental monitoring, land management and sustainable practices. Remote sensing, GIS (Geographic Information Systems) and mobile applications can help in monitoring biodiversity, tracking land use and collaborating on conservation initiatives.

Implication

The implications of this study show that ICT education in the Orang Asli community is not just a technological intervention, but a fundamental component in the effort to achieve sustainable development, reduce inequality and strengthen the cultural identity of indigenous peoples. First, the results of the study emphasize that ICT should be seen as a basic requirement of modern education that can reduce the digital gap between the Orang Asli community and the mainstream society. This implication is important for policymakers, especially in ensuring that the provision of digital infrastructure and internet access is equitably coordinated in rural areas. Second, this study provides implications for the education sector, especially for teachers and teacher training institutions, that culturally responsive pedagogy needs to be the basis for ICT curriculum planning. Without an approach that respects traditional knowledge, belief systems and cultural values, the implementation of ICT risks failing to achieve learning objectives and not being accepted by the community. Third, this study has important implications for community empowerment. By ensuring that ICT is implemented through a community-centered approach, it can serve as a tool to strengthen the capacity of the Orang Asli community to make decisions, engage in digital participation, and maintain control over their own cultural narrative. This implication also shows the need for collaboration between governments, NGOs, educational institutions and communities to develop more sustainable and effective digital initiatives. Finally, this study reinforces the principle that ICT integration needs to be aligned with the goal of cultural conservation. By using ICT as a medium for documentation, learning and the transfer of traditional knowledge, the cultural identity of Orang Asli can be preserved in the digital age. All of these implications emphasize that ICT is not only important for academic development, but also plays a critical role in shaping an inclusive, resilient and sustainable future for Orang Asli communities.

CONCLUSION

In conclusion, ICT education has great potential to change the learning landscape in the Orang Asli community, not only as a medium for imparting knowledge, but also as a tool for social, economic and cultural empowerment. However, this potential can only be realised if its implementation is not seen simply as an agenda for providing technology or infrastructure, but as a holistic process that takes into account the identity, values and epistemology of the Orang Asli community itself. The results of the analysis show that the success of the use of ICT in the education of this community depends on the ability of the education system to integrate technology in a way that

respects their cultural sensitivities and traditional ways of life. This requires a deeper approach based on the principles of digital inclusion, culturally responsive pedagogy, and a clear understanding of the factors of technology acceptance as explained in the Technology Acceptance Model (TAM) framework. The use of ICT should also be seen as an opportunity to bridge the gap between traditional knowledge inherited from generation to generation and the digital skills needed in the modern era. If implemented sensitively and with foresight, ICT can function as a platform to preserve, document and restore the cultural heritage of the Orang Asli, while opening up new learning spaces that increase the digital literacy and competitiveness of the younger generation. At the same time, any intervention needs to ensure that the digitalization process does not erode identity or marginalize indigenous knowledge systems that have proven relevant for centuries. Finally, this study emphasizes that future research needs to prioritize participatory research approaches led by communities themselves, so that the voices of Orang Asli are not only heard, but become the basis for designing, implementing and evaluating ICT initiatives. Only in this way can ICT function as a truly meaningful, ethical educational vehicle that contributes to the sustainable development and well-being of the entire Orang Asli community.

RECOMMENDATION

Based on the analysis conducted, several recommendations are put forward to strengthen the role of ICT in Orang Asli community education in a more effective and ethical manner. First, future research should prioritize a participatory action research (PAR) approach that provides space for Orang Asli to be directly involved as research partners, not just respondents. This approach is important to ensure that the design, content and use of ICT truly reflect their needs, aspirations and cultural sensitivities. Second, further research should focus on developing a culturally responsive pedagogical model that integrates indigenous knowledge with mainstream digital content. This model not only has the potential to increase learning motivation, but can also ensure that the use of technology does not erode the cultural identity of the community. Third, research also needs to assess the factors of technology acceptance in more depth by using frameworks such as the Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT) or Indigenous Knowledge Systems (IKS) as a basis for measurement. Such studies can help to understand more specifically how cultural beliefs, community experiences and levels of digital literacy influence the acceptance of ICT in the educational context. Fourth, long-term empirical studies are needed to evaluate the effectiveness of ICT interventions on academic achievement, social empowerment, cultural preservation and community well-being. Finally, future research should explore the potential use of new technologies such as mobile applications, virtual reality, multimedia documentation and community-based learning platforms as a medium for preserving cultural heritage and strengthening the digital literacy of the younger generation of Orang Asli.

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REFERENCES

1. Abdullah, N., & Derus, N. (2020). Digital inclusion and Indigenous communities: Barriers and opportunities in Malaysia. *Journal of Information Technology Education*, 19(2), 145–162. <https://doi.org/10.28945/4543>
2. Adams, D. (2022). Education in Malaysia. London: Routledge.
3. Ahmed, S., Hussain, M., & Karim, A. (2021). The transformative impact of information and communication technologies on modern societies: A multidimensional review. *Journal of Information Systems and Technology Management*, 18(3), 1–15. <https://doi.org/10.4301/S1807-177520211803>
4. Bala, P., & Tan, C. E. (2021). Digital inclusion of the Orang Asli of Peninsular Malaysia: Remote virtual mechanism for usability of telecentres amongst indigenous peoples. *The Electronic Journal of Information Systems in Developing Countries*. <https://doi.org/10.1002/isd2.12171>
5. Battiste, M. (2013). Decolonizing education: Nourishing the learning spirit. Purich Publishing.

6. Benjamin, R. (2019). *Race After Technology: Abolitionist Tools for the New Jim Code*. Polity Press
7. Bow, C., & Hepworth, P. (2019). Observing and respecting diverse knowledge traditions in a digital archive of Indigenous language materials. *Journal of Copyright in Education & Librarianship*, 3(1).
8. Carretero, S., Vuorikari, R., & Punie, Y. (2017). *DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use*. Publications Office of the European Union. <https://doi.org/10.2760/38842>
9. Çetinkaya, M. (2025). A methodological approach to content analysis of qualitative data in science education: An applied example. *Pedagogical Perspective*, 4(1), 197–209. <https://doi.org/10.29329/pedper.2025.86>
10. Clothey, R. A. (2014). ICT and Indigenous Education: Emerging Challenges and Potential Solutions. In *Indigenous Education* (pp. 63–75).
11. Deja, A., Szeląg, M., & Wiśniewski, M. (2021). The role of ICT in organizational performance and innovation: A systematic review. *Technological Forecasting and Social Change*, 164, 120498. <https://doi.org/10.1016/j.techfore.2020.120498>
12. Dyson, L. E. (2012). Indigenous peoples and digital technologies: A contextual approach. *Information Technology & People*, 25(4), 347–358.
13. Freire, P. (2009). From pedagogy of the oppressed. *Race/ethnicity: multidisciplinary global contexts*, 2(2), 163–174.
14. Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice* (3rd ed.). Teachers College Press
15. Hadi, F.-S., Jatiningrum, C., Mohamad Harizan, N. A., Muhammad, F., Yien Yin, K., Pei-Tha, G., & Hudin, N. S. S. (2024). Enhancing the Financial Performance of Orang Asli Entrepreneurs in Malaysia through Digital Marketing Initiatives. *International Journal of Academic Research in Business and Social Sciences*, 14(12). <https://doi.org/10.6007/IJARBSS/v14-i12/23767>
16. Hasbie, S. N. R., Adam Assim, M. I. S., Taasim, S., & Anuar, F. N. (2023). Information and Communication Technology (ICT) Adoption and Community: A Systematic Literature Review. *International Journal of Academic Research in Business and Social Sciences*, 13(15), 153–167. <https://doi.org/10.6007/IJARBSS/v13-i15/18799>
17. Humble, N., & Mozelius, P. (2022). Content analysis or thematic analysis: Doctoral students' perceptions of similarities and differences. *Electronic Journal of Business Research Methods*, 20(3), 89–98. <https://doi.org/10.34190/ejbrm.20.3.2920>
18. Ismail, Z., & Azizan, S. N. (2020). Digital inequality among Indigenous learners in Malaysia: Barriers and opportunities. *Malaysian Journal of Learning and Instruction*, 17(2), 89–112.
19. JAKOA. (2019). Statistics of the Orang Asli community in Malaysia. Jabatan Kemajuan Orang Asli.
20. Jamaludin, F. I. C., Abdullah, M. R. T. L., Endut, M. N. A. A., Zulkefli, M. I. I., & Zulkipli, S. (2025). Development of impact assessment instruments for renewable energy investments in Orang Asli communities. *Journal of Nusantara Studies (JONUS)*, 10(1), 443–465.
21. Kamsin, I. F. (2023). ICT skills among Indigenous students. *International Journal of Academic Research in Progressive Education and Development*, 12(3). <https://doi.org/10.6007/IJARPED/v12-i3/19295>
22. Kent, A. J., & Specht, D. (Eds.). (2023). *The Routledge handbook of geospatial technologies and society*. Routledge.
23. Kohsaka, R., & Rogel, M. (2019). Traditional and local knowledge for sustainable development: Empowering the indigenous and local communities of the world. In *Encyclopedia of the UN Sustainable Development Goals* (pp. 1–13). Springer Nature.
24. Kral, I. (2012). *Talk, text and technology: Literacy and social practice in a remote Indigenous community*. Multilingual Matters.
25. Kukutai, T., & Taylor, J. (Eds.). (2016). *Indigenous data sovereignty: Toward an agenda*. ANU Press.
26. Luaran, J. E., Ahmad Nadzri, F., Mohd Rom, K. B., & Jain, J. (2016). The importance of Information and Communication Technology in English learning: Indigenous students' perspectives. *Malaysian Journal of Distance Education*, 18(1), 87–101.
27. Mahmud, M., Ismail, H., & Azizan, S. N. (2022). Integrating ICT into Indigenous education in Malaysia: Challenges and opportunities. *Asian Journal of Education and e-Learning*, 10(1), 23–35. <https://doi.org/10.32933/ajee.2022.10.1.3>

28. Masron, T., Masami, F., & Ismail, N. (2013). Orang Asli in Peninsular Malaysia: Population, Spatial Distribution and Socio-Economic Condition. *Ritsumeikan Social Sciences and Humanities*, 6, 75–98.
29. McMahon, R. (2014). Digital self-determination and Indigenous peoples. *Media International Australia*, 151(1), 132–145.
30. Mignone, J., & Henley, H. (2009). Impact of ICT on Indigenous communities: A participatory approach. *Journal of Community Informatics*, 5(2), 1–12.
31. Nicholas, C., Engi, J., & Teh, Y. P. (2010). The Orang Asli and the contest for resources: Indigenous politics, development, and identity in Peninsular Malaysia. *IWGIA*.
32. Özdemir, O. (2025). Kahoot! Game-based digital learning platform: A comprehensive meta-analysis. *Journal of Computer Assisted Learning*, 41(1), e13084.
33. Resta, P., & Laferrière, T. (2015). Digital equity and intercultural education. *Education and Information Technologies*, 20(4), 743–756. <https://doi.org/10.1007/s10639-015-9419-z>
34. Revathi, K., & Aithal, A. (2019). Role of ICT in global economic development: An overview. *International Journal of Applied Engineering Research*, 14(21), 4038–4045. https://www.ripublication.com/ijaer19/ijaerv14n21_07.pdf
35. Russo, K., Watkins, J., & Groundwater-Smith, S. (2014). Digital inclusion for Indigenous youth: Cultural and educational perspectives. *Computers & Education*, 76, 1–10.
36. Saha, C. (2023). Technology integrated language teaching in rural areas in Bangladesh-expectation versus reality (Doctoral dissertation, Brac University).
37. Selwyn, N. (2016). Education and technology: Key issues and debates. Bloomsbury.
38. Warschauer, M. (2003). Technology and social inclusion: Rethinking the digital divide. MIT Press.
39. Walid, N. (2021). A new conceptual model of technology usage for indigenous (TUfl): The case of the Orang Asli in Peninsular Malaysia (Doctoral dissertation, Universiti Teknologi MARA). Universiti Teknologi MARA Institutional Repository.
40. Welch, M., & Saltmarsh, J. (2023). Engaging higher education: Purpose, platforms, and programs for community engagement. Routledge.