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RESEARCH ARTICLE

Teachers' Perceptions of the Cruciality of Digital Leadership Among Principals in Sabah, Malaysia: A Quantitative Study

Fung Lan Yong[1*], Chun How Chin[2], Florence Chuah[3]
Loreta Ling Ling Uie[4], Yuk Fong Chin[5]

[1]Postgraduate Studies, Jesselton University College, 88300 Kota Kinabalu, Sabah, Malaysia
Email: fungyong@jesselton.edu.my
[2]Academic Department, AMC University College, 88400 Kota Kinabalu, Sabah, Malaysia
Email: hoa.qa@amccolllege.edu.my
[3]Inclusive GEMS Consultancy, 46200 Petaling Jaya, Selangor, Malaysia
Email: florencecsy@gmail.com
[4]Business Studies, Jesselton University College, 88300 Kota Kinabalu, Sabah, Malaysia
Email: loretaling8383@gmail.com
[5]President's Office, Jesselton University College, 88300 Kota Kinabalu, Sabah, Malaysia
Email: fred@jesselton.edu.my

CORRESPONDING AUTHOR (*):
Fung Lan Yong
(fungyong@jesselton.edu.my)

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ABSTRACT

The primary aim of this study was to examine teachers' perceptions of the cruciality of digital leadership among principals in Sabah, Malaysia. The sample consisted of 102 secondary school teachers from Sabah, Malaysia who completed the Multifactor Digital Leadership Questionnaire (MDLQ). Non-parametric tests showed no significant differences in teachers' perceptions in terms of gender, age, and job experience; significant differences were only found by way of teachers' qualifications at $p < 0.05$. Wilcoxon signed rank test showed that all 47 MDLQ items were significant at $p < 0.001$ with medians significantly different from the hypothesized value of 3.5, indicating strong agreement. A high of 90.3 to 91.2 percent of teachers tended to perceive that it was highly crucial/crucial for principals to (1) adopt a solution-based approach, (2) stay abreast on the latest technological tools and trends, and (3) demonstrate knowledge of value creation. Additionally, 42 of the items had 81.4 to 89.2 percent of teachers who perceived that it was highly crucial/crucial for principals to demonstrate the characteristics and attributes of digital leadership. In light of the findings, several recommendations were made on how principals in Sabah could improve their digital leadership.

Contribution/Originality: This research offers a valuable contribution by examining teachers' perceptions of the cruciality of digital leadership among secondary school principals in Sabah, Malaysia. It narrows the gap that exists in the digital leadership literature by highlighting the urgent need for digital leadership training among school principals so that they can demonstrate cyber civility and digital citizenship to inspire innovation and change within the Malaysian educational milieu.

1. Introduction

In 2024, Malaysia experienced a transformative shift in its digital milieu characterized by momentous investments, visionary enterprises, and progressive policies that have reshaped the nation's digital and technological ecosystem. Emerging as a regional leader in the digital economy, it is attracting global attention and reaffirming investor confidence in its potential. Global digital powerhouses, such as Amazon Web Services, Google, and Microsoft have committed or expanded their investments in the country, which further solidy its locus as a premier destination for digital-driven growth. Moreoever, the government has launched the Central Database Hub to promote digital technology via the provision of a safe, comprehensive, and national main database, thus allowing the production of more accurate data analytics. It has also unveiled the National Semiconductor Strategy to realize the country's aspiration to become a major global player in digital technology powered by the semiconductor industry. In addition, its National Cloud Policy is expected to fuel economic expansion by endorsing businesses, reinforcing user trust and data security, and empowering citizens through digital inclusivity. Also aiming to position Malaysia as a hub for generative AI, the government has increased its funding for AI-related education at research universities and vocational training at electrical and electronics institutions (Malay Mail, 2024).

To drive and sustain the knowledge economy, there is an urgent need for Malaysian school leaders to drive and sustain various digital transformation initiatives to attain greater educational development and success. Characterized by rapid change, the digital age constantly challenges the way school leaders conceptualize and execute their roles since they can no longer rely on hierarchical power and structured processes to govern a school in the current sociocultural milieu that disregards structure and authoritarian leadership, but rewards innovative thinking and critical problem-solving. Principals need to see this change as an opportunity to adopt a cutting-edge leadership style that is technologically savvy to promote digitally sustainable initiatives; they need to become not only more people-centric, but are also ready to take calculated risks in evolving and ambiguous settings. Additionally, they also need to demonstrate strong situational and emotional awareness that allows them to empower staff to experiment with innovative ideas, besides creating a focused and supportive environment for everyone to pursue a strong future vision and mission (Korn Ferry Institute, 2018).

A review of literature shows that a gap exists in digital leadership among principals who are compellingly needed to lead change in Malaysian schools where digital competencies are indispensable for enhancing the teaching and learning process. Effective digital leadership requires principals who can display online self-awareness and congruence, while demonstrating cyber civility and digital citizenship to inspire innovation and change within the Malaysian education context. They need to integrate digital leadership into their daily functions to effectively confront the challenging boundaries, roles, and possibilities to promote Malaysia as a higher education hub and exporter in the global arena. In brief, they need to exhibit digital citizenship behaviors to effectively interact with digital-age students, parents, and other stakeholders with strong moral-ethical values (Korn Ferry Institute, 2013).

According to Petrucci and Rivera (2018), many business schools still focus on managing performance rather than leading growth; nevertheless, the iGen is increasingly taking over the workforce with leadership trends that will reshape organizational leadership. Modern organizations require digitally-minded leaders who can face the rapid

organizational pace, as well as, the increasingly complex leadership processes. Digitally-minded leaders are imperative to address such trends as advanced people analytics, agile team networks, real-time feedback, individualized learning, and artificial intelligence, with distinctive emphasis on shared values and vision, change management, and talent development to fulfil organizational goals.

Goh and Mansor (2024) appraised that there is a disjoint between digital leadership and its actual adoption in schools despite its increasing significance in education. For example, teachers tend to perceive that principals are not effectively promoting the strategic use of digital technology in the teaching and learning process, thus reflecting an urgent need to bridge the gap by strengthening the link between digital leadership and its actual implementation at schools. Additionally, principals should become digital transformative drivers to propagate a culture of innovation and experimentation amongst staff, students, parents, and other stakeholders. Since they shoulder the fundamental responsibility in promoting digital transformation at schools, it is imperative for principals to prioritize staff's digital knowledge and skills; for example, by inculcating digital literacy, technological efficacy, and positive digital attitudes, while scaffolding staff via team and individual initiatives. Since many rural schools in Sabah still seriously lack digital teaching and learning platforms, local principals should strive to improve their knowledge on, and attitudes toward, the role, attributes, and implementation of digital technology at schools.

1.1. Significance of the Study and Research Objectives

There is a need for a more in-depth examination of the strategies and best practices that principals should adopt to successfully implement digital leadership in schools. The existing literature has highlighted the necessity of digital technology use, managerial and individual skills, adaptive leadership, and various digital competencies; however, it does not adequately address how these dimensions can be effectively incorporated into school leadership. A significant gap also appears in the literature that discusses the cruciality of digital leadership and cost-effective measures for implementing it (Goh & Mansor, 2024).

This study is significant for the following reasons. There is a dearth of empirical research on digital leadership in Malaysia, especially in the context of secondary education in Sabah. This study will offer practical insights for adopting digital leadership to improve pedagogic practices and school management, which in turn, can drive positive change and innovation in Sabah's educational landscape. It also contributes to the existing literature by providing quantitative evidence on the extent of digital leadership among principals in the state. While previous research offers insight into digital leadership and its role in the educational domain, this study will reduce the knowledge gap by assessing teachers' perceptions of the cruciality of the digital leadership among principals in the resource-scarce state. Lastly, findings of this study will generate deeper insight into the role of digital leadership in enhancing principals' propensities and management practices that can lead to greater institutional sustainability and academic success. The main research objectives of this study were to determine the (1) influence of digital leadership by way of teacher demographics, (2) significance of the Multifactor Digital Leadership Questionnaire (MDLQ) that was specifically developed to fulfil the purpose of the study, and (c) percentages of agreement on the 47 items of the MDLQ.Three research questions were formulated to guide the study:

i. Were there any significant differences in teachers' perceptions of the cruciality of digital leadership among principals in Sabah by way of gender, age, job experience, and qualifications?
ii. Were there any significant differences in the MDLQ items based on a hypothesized value of 3.5?
iii. What were the percentages of agreement (highly crucial/crucial) on the items and their implications?

2. Review of Literature

2.1. Characteristics and Teachers' Perceptions of Digital Leaders in Education

Since the Malaysian educational sector is now increasingly digitalized, school leaders can longer maintain traditional educational leadership styles; instead, they must promptly incorporate technology into their management practices to demonstrate digital leadership competence and self-efficacy. The increasing speed of operation and transformation in the educational landscape requires them to explore new opportunities enabled by rapid digitalization, while schools are expected to capitalize on a broad array of digital services to strengthen their organizational capability and sustainability. As a workforce feeder to the digital economy, education primarily requires leaders who can practice digital leadership to enhance staff performance, student achievement, and community service in a rapidly evolving digital milieu.

A study by Aksal (2015) examined the perceptions of digital roles among headmasters working in primary and secondary schools. Findings showed that headmasters tend to perceive digital leadership differently from traditional leadership, while demonstrating awareness of digital leadership and technological changes; they also imply that they are willing to incorporate communication technologies and digital management as part of the school culture. On the other hand, Zhong (2017), who examined the digital leadership performance indicators among three K-12 principals in relation to instructional technology, revealed that (1) visionary leadership tends to be perceived as a form of integrated technology supported by stakeholders, (2) the digital age learning culture tends to be reinforced by technological modelling and effective utilization of technology, (3) professional development tends to be augmented by digital learning opportunities, and (4) systemic improvement in digital leadership tends to yield greater learning achievement, more competent staff, and more strategic partnerships.

2.2.1. Digital Leadership by Transformational Leaders

While investigating the most promising leadership style for the successful implementation of digital leadership, Ehlers (2020) found that transformational leadership tends to be a prominent model, implying that it tends to be highly effective in addressing the complex nature and processes involved in the digital transformation in higher education institutions (HEIs). It allows HEI leaders to define and implement the digital technologies amongst all stakeholders to build a sustainable structure by fostering various management competences, such as, knowledge management, delegating, sense making, and collaboration. Lastly, digital leadership tends to be particularly suitable for transitioning HEIs from stable entities into resilient and sustainable ones, thus enabling them to realize organizational innovational and change in the Malaysian milieu.

Additionally, Ehlers (2020) asserted that transformational leaders can successfully support change processes as the creative force behind digitalization; they bring attention to the consequences of change and uphold common standards to reduce resistance to change. Moreover, they are able to connect with staff to increase job motivation and morality, while focusing on public interest and staff self-actualization. Overall, transformational leadership offers a solid framework for digital leadership as it focuses on effective communication and participation, which are crucial in metamorphosing higher education into a dynamic digital culture.

Antonopoulou et al. (2021a) researched the characteristics of digital leaders and transformational leadership in higher education. Findings indicated that digital leadership tends to be positively correlated with transformational leadership, while a high degree of transformational leadership tends to be related to greater implementation of digital leadership practice. Findings imply that tertiary institutions should modify their practices to adequately adapt in the era of digital technology. Further, Klus and Müller (2021) who examined the relationship between digital skills and coping ability toward specific problems, discovered that digitization-related challenges faced by executives tend to be related to the introduction of new digital processes, adoption of a digital mindset, and digitization of procedures. Moreover, female executives tend to rate their organizational ability to be higher than that of their male counterparts, while technical competence tend to be rated higher among male executives. Organizational skills tend to be the weakest among executives under 30, which reflects the importance of job experience in this context. Lastly, preferred attributes of executives tend to include greater assertiveness, motivational skills, digital competence, and organizational skills, besides the ability to predict the future and make strategic decisions in the face of constant change.

2.2.2. Teachers' Perceptions of Digital Leadership

On the other hand, Hamzah, Nasir, and Wahab (2021), who examined digital leadership among principals as well as digital teaching practices among teachers in Malaysia, found that principals with higher digital leadership tend to significantly inspire a higher level of digital instruction among teachers. Additionally, teachers' digital instruction tends to explain 30 percent of the variance in principals' digital leadership, with digital citizenship acting as the strongest predictor of digital instruction. Overall findings imply that principals tend to display various digital leadership attributes, including visionary leadership, digital learning culture, digital citizenship, and professional excellence. Additionally, Tajuddin et al. (2022), who examined the expected key employability skills of fresh graduates in communication and media among middle and top-level managers, found that organizational leaders tend to expect graduates to display effective digital leadership and interpersonal communication skills, implying that education providers should prepare students to drive innovation and change in the digital world.

A study by AlAjmi (2022) that examined the relationship between digital leadership and teachers' technology integration among both principals and teachers, revealed that principals tend to practice proactive visionary leadership, promote a digital learning culture, and inculcate digital citizenship at school and in the general community, while prioritizing professional excellence and systemic improvement. Lastly, digital leadership also tends to be significantly associated with teachers' digital integration, with highly digital leaders allocating more resources and time to promote digital agility and functional usage of technology and media.

Hamzah et al. (2021), who conducted a quantitative study to assess teachers' level of digital leadership, revealed that both administrators and teachers tend to display a high level of digital leadership and proficiency in their digital teaching practices, respectively. Besides, findings also highlighted the importance of strategizing and structuring digital leadership initiatives that can bolster academic performance and learning motivation via hybrid teaching and learning. On the other hand, in their investigation into teachers' perceptions of principal's digital leadership and their own technological abilities, Karakose, Polat, and Papadakis (2021) revealed that teachers tend to regard principals' digital technology use as adequate. Additionally, they also tend to perceive principals as supportive with regard to digital transformation and professional development, thus promoting a favorable digital outlook. Findings imply that principals' digital leadership skills appear to revolve around technological application and management skills needed to augment digital transformation at schools. Lastly, Goh and Mansor (2024), who investigated primary school teachers' perceptions of digital leadership among principals, disclosed that principals' overall level of digital leadership tends to be high, implying that schools have great potential in integrating digital technology into the teaching and learning process, which in turn, can promote continuous innovation and change in education. Overall, findings underscore the importance of developing digital leadership skills amongst teachers and principals to enhance pedagogic practices and curricular development, besides organizational management to drive novel paradigm shifts and inventive breakthroughs in the educational landscape.

A research paper by Nubun, Hassan, and Hamidi (2024) investigated Malaysian teachers' perceptions of school administrators' digital competencies and digital maturity of selected schools. Findings showed that digital leadership competencies among the school administrators tend to encompass several dimensions, including (1) vision and mission, (2) digital culture, (3) digital professional development, (4) digital progress, (5) digital safety, and (4) digital resilience. Moreover, digital maturity in the selected school tends to be at "Level 3 – Management" that supports the process of continuous development, but has not reached continuous enhancement yet. Findings imply that it is critical to empower and upgrade the competencies of school administrators to uphold the nation's educational policies and initiatives. Besides, a recent study by Goh and Mansor (2024) indicated that the overall level of digital leadership among Malaysian school administrators tends to be high, thus indicating great potential for integrating digital technology into the management processes at schools. Findings reflect the cruciality of enhancing school leaders' digital leadership skills needed to drive ongoing innovation and change in education, while underscoring the urgency to develop and implementing pragmatic digital leadership strategies that can augment organizational management in the digital era.

2.3. Impact of Digital Leadership

While examining the synergies between undergraduate students and tutors in relation to digital leadership skills, Dimitriad (2019) discovered that (1) student-tutor interactions tend to increase students' understanding of digital citizenship as a social responsibility, (2) such interactions tend to allow students to see the critical role of digital leadership in underscoring the application of innovative and safe technology, (3) tutors tend to acquire the necessary technological literacy to become confident digital leaders with deeper insight into social media as a teaching tool, and (4) digital leadership tends to promote constructivist learning through sharing. Moreover, Omar, Ismail, and Kasim (2019), who examined the relationship between principal technology leadership and self-efficacy

among teachers, discovered that the level of principals' technology leadership and teachers' self-efficacy tend to be high. Additionally, findings also showed that a significant, but modest positive relationship tends to exist between principals' technology leadership and teachers' self-efficacy, with digital age learning culture and digital citizenship for technology leadership exerting the strongest influence on teachers' self-efficacy.

In their study, Yusof et al. (2020) investigated the impact of digital communication on the relationship between principal leadership and community collaboration among teachers and other stakeholders. Findings revealed that principal leadership contributed significantly to digital communication, with WhatsApp, Telegrams, and Facebook significantly mediating the relationship between principal leadership and collaboration among stakeholders. Additionally, Saputra et al. (2021), who studied the impact of digital leadership and collaboration on digital skill development among office workers, concluded that digital collaboration tends to significantly impact digital skills development, implying that educational leaders should encourage staff to intensively collaborate by adopting digital technology to accelerate the process.

On the other hand, Omar and Ismail (2020) assessed the impact of principals' technology leadership on secondary school teachers' mobile technology integration in the teaching process by way of visionary leadership, digital age learning culture, excellence in professional practice, systemic improvement, and digital citizenship. Findings revealed a strong positive relationship between teachers' mobile technology integration and principals' technology leadership. Lastly, findings also indicated that visionary leadership, digital citizenship, and systemic improvement tend to significantly influence teachers' mobile technology integration.

In their investigation into the influence of digital leadership on the performance outcomes of private higher education institutions (PHEIs) among tertiary administrators, Lim and Teoh (2021) focused on the roles of visionary leadership, professional excellence, digital learning culture, systemic improvement, and digital citizenship. Findings showed that digital learning culture, professional excellence, and digital citizenship tend to significantly influence performance outcomes, implying that PHEI leaders should reinforce the concepts of digital learning culture, digital citizenship, and professional excellence for their institutions to thrive in an emerging market.

Jostein and Niki (2021), who studied the impact of digital transformation on the information technology (IT) organizational structure and leadership in pre-digital organizations in the UK and Scandinavia, found that four categories of IT organizational structure and leadership tend to follow digital transformation initiatives, including digital projects within the IT function, IT and digital functions with separate leaders, IT and digital management within one function with dual leadership, and IT and digital functions with single leadership.

In their study on the impact of traditional and digital leadership on university leaders, Antonopoulou et al. (2021b) revealed that digital leadership had a significant correlation with leadership outcomes, whereby high efficiency and satisfaction tend to coexist with high implementation of digital leadership. Moreover, leadership outcomes tend to have a significant impact on digital leadership, whereby leadership effectiveness and satisfaction tend to increase proportionately with digital leadership. Lastly, efficient and satisfied leaders tend to take greater advantage of social media, mobile apps, and web development and tools. Additionally, Jagadisen et al. (2022), who studied the impact of digital

leadership on dynamism, innovation, and alliances among manufacturing organizations in Malaysia, implying that digital leadership tends to have a significant impact on alliance, innovation, and dynamic capabilities; hence, organizational leaders should align their various capabilities with digital technology to increase their competitive advantage and corporate opportunities.

Abdul Musid, Mohd Matore, and A. Hamid (2023) examined the impact of the Quadruple Helix Model in promoting digital leadership in Malaysia. Findings implied that various barriers in digital leadership could be overcome with adequate funding and well-developed infrastructure, additional research, and the use of digital leadership tools, as well as support from the private and public sectors in the form of funding/professional services, positive parental attitudes, and effort renewals. Further, leaders also need to demonstrate the ability to implement, revise, and improve the education policies in relation to digital and technology, quality of teachers teaching, students' engagement, and parental involvement. Consequently, all stakeholders, including the government, universities, industries, and civil society, must play their respective roles more actively to promote digital leadership in the nation. Lastly, future research should examine how prepared the various parties are in promoting digital innovation and technology in education. On the other hand, Yakob and Don (2025) examined the influence of digital leadership on the professional identity and branding of public university education programs in Malaysia. Findings showed that digital leadership tends to have an impact on professional identity and branding of public university education programs, with professional identity acting as a partial mediator between the relationship between digital leadership and branding.

Finally, Hamzah, Radzi, and Oma (2025) explored the impact on, and barriers faced by, Malaysian school principals as digital leaders, besides analyzing the need for developing a digital leadership competency model. Findings revealed that the key obstacles to integrating digital technology into schools tend to range from financial. technical, and cultural to operational issues, with significant problems in terms of a digital skills gap among teachers, financial constraints, and obsolete infrastructure. Further predicaments arise from the lack of continuous technical support, attitudes toward digital technology and noncompliance of parents and the community. Nevertheless, effective digital leadership competencies among principals can be developed by having clear guidelines for leadership, self-assessment tools for principals, and frameworks addressing ethics and cybersecurity, while collaboration, networking, and community engagement should be increased to overcoming any digital quagmire.

3. Methodology

3.1. Research Design and Approach

This study adopted a quantitative research approach, using an online questionnaire to gather numerical data for statistical analysis. This method allowed for the calculation of significant differences based non-parametric tests and percentages of agreement on teachers' perceptions of digital leadership among principals. Additionally, this study was based on a positivist research paradigm because it focused on objective measurement, statistical analysis, and empirical evidence. This particular design was appropriate because it could be applied to capture teachers' perceptions within a short period.

3.2. Research Locations

The research was conducted in two locations, namely, Kota Kinabalu and Kudat. Both were chosen for their position as highly accessible locales that are deemed representative of the teaching workforce in Sabah. Kota Kinabalu is the capital city situated strategically in the west coast of the same island state (Sabah Tourism Board, n. d.-a). On the other hand, Kudat, also known as the Tip of Borneo, is located on the upper north of the Malaysian state of Sabah (Sabah Tourism Board, n. d.-b).

3.3. Sample and Justification

The sample was obtained through convenience sampling whereby teachers were selected for inclusion because they were the easiest for the first author to access. Further, this sampling method was adopted because of cost-effectiveness, feasibility, geographical proximity, availability of teachers at the given time, and willingness of both teachers and principals to participate in the research. Forty-one (41) teachers in Kota Kinabalu were recruited with the help of three principals who were asked to share the survey link with teachers and urge them to respond to the questionnaire online. Another 61 teachers in Kudat were asked to fill out the questionnaire with a pen/pencil after attending a presentation on effective teachers and teaching strategies by the first author.

The sample size of this study was limited to 102. Nevertheless, according to Roscoe (1975), a sample size greater than 30 and less than 500 is suitable for most survey studies; the argument behind this rule of thumb is derived from the central limit theorem (CLT), which states that the distribution of means will reach a normal distribution as the sample size increases. This rule of thumb was applied by RUBIKTOP (2023), a prominent market research company committed to delivering high-quality, actionable data. First, the CLT provides a good approximation of the sampling distribution of the mean for the current sample size of 102, which indicates that the normal distribution can be used to calculate confidence intervals and *p*-values for the findings. Second, for most statistical tests in education, the probability of rejecting the null hypothesis when it is true (Type I error) is controlled at a significant level of 0.05; therefore, the current researchers are willing to accept a five (5) percent chance of making a Type I error (rejecting the null hypothesis when it is actually true). With the current sample size, this level of control for most statistical tests can be achieved. Third, the power of a statistical test also lies in its probability of rejecting the null hypothesis when it is false (Type II error). Since power can be reasonably derived from a minimal sample size of 30, the present sample will yield relatively high power. Lastly, a minimal sample size of 30 can help achieve a reasonable level of power for non-parametric tests; therefore, the current sample would be sufficient to indicate significant differences for the Kruskal-Wallis H, Mann-Whitney U, and Wilcoxon signed rank tests that were utilized to analyze data in this study.

Teachers come from a variety of backgrounds and possess different levels of experience and expertise, thus reflecting a wide range of perspectives on perceptions of digital leadership within their schools. Males comprised 49, while females comprised 51 percent of the sample. Age-wise, 38.2 percent are 22 to 33 years old, 32.4 percent are 34 to 44 years old, 20.6 percent are 45 to 55 years old, and 8.8 percent are 56 and above. With regards to job experience, 23.5 percent have worked for 1 to 5 years, 28.4 percent for six to 11 years, 19.6 percent for 18 to 23 years, and 16.7 percent for more than 23 years. About 15.7 percent have earned a diploma, 52.9 percent a bachelor degree, 21.6 percent a master degree, and 9.8 percent a PhD (see Table 1).

Table 1: Demographic Characteristics of Teachers (n = 102)

Variable	Category	Frequency	Percentage
Gender	Male	50	49.0%
	Female	52	51.0%
Age	23-33	39	38.2%
	34-44	33	32.4%
	45-55	21	20.6%
	56 and above	9	8.8%
Job experience (years)	1-5	24	23.5%
	6-11	29	28.4%
	12-17	20	19.6%
	18-23	12	11.8%
	More than 23	17	16.7%
Highest qualification	Bachelor	54	52.9%
	Master	22	21.6%
	PhD	10	9.8%
	Diploma	16	15.7%

3.4. Instrument

The primary data collection tool for this study was the Multifactor Digital Leadership Questionnaire (MDLQ), which consists of consists of 47 Likert-scale items ranging from not crucial at all = 1, not crucial = 2, neutral = 3, crucial = 4 to highly crucial = 5 (Yong, et al., 2025). To determine its readability and reliability for this study, a pilot test was conducted by administering it to 20 teachers. Data were analyzed using SPSS 26.0 and results indicated that its Cronbach value was 0.97, which signified its high internal consistency.

3.5. Data Collection and Analysis

Data collection was carried out by requesting Kudat teachers to circle their answers on their hardcopy using a pen or pencil, while the Kota Kinabalu teachers were reminded by their principals to complete the questionnaire on Google Forms. Further, research conditions and confidentiality concerns were clearly and succinctly communicated to the respondents, who were assured of their anonymity, while their responses would be kept strictly confidential. They were also told that they could stop participating in the survey any time. Data collection was done during lunch break that allowed sufficient time for the teachers to respond or ask questions.

Subsequently, the available data were recorded on a spreadsheet and double-checked to ensure accuracy; they were then analyzed using SPSS 29.0. Both descriptive and inferential analyses were conducted. First, descriptive statistics was used to summarize demographic information, including gender, age, job experience, and qualifications. This analysis provided valuable insight into the attributes of the sample and contributed to greater understanding of the general characteristics of the teachers. Second, inferential statistics was conducted by running non-parametric tests, namely, Mann-Whitney U, Kruskal-Wallis H, and Wilcoxon signed rank test on determine significant differences in terms of gender, age, qualifications, and job experience, respectively. Additionally, Wilcoxon signed rank test was conducted to determine the level of significance of each digital leadership item by using a hypothesized value of 3.5. Lastly, percentages of agreement (highly crucial/crucial) of each item were collapsed to gain an overall

impression of teachers' perceptions of the cruciality of digital leadership among principals.

4. Findings

4.1. Non-parametric Test Results

Non-parametric tests showed no significant differences in teachers' perceived cruciality of digital leadership among principals by way of gender, age, and job experience. Significant differences were only found in terms of teachers' qualifications at $p < 0.05$ (see Table 2).

Table 2: Mann-Whitney U and Kruskal-Wallis H Results

Variables	Non-parametric test	*p*-value
Gender	Mann-Whitney U test	0.399
Age	Kruskal-Wallis H test	0.865
Job Experience	Kruskal-Wallis H test	0.240
Highest qualification	Kruskal-Wallis H test	0.026*

*$p < 0.05$

Wilcoxon signed rank test showed that all MDLQ items were significant at $p < 0.001$, with medians significantly different from the hypothesized value of 3.5, thus indicating strong agreement (see Table 3).

Table 3: Wilcoxon Signed Rank Test (Hypothesized Value = 3.5)

It is crucial for principals to	*p*-value
Stay up-to-date on the latest technological tools and trends	< 0.001*
Evaluate the impact of new technologies on their organizations	< 0.001*
Use data for effective decision-making	< 0.001*
Assess and manage risks related to data privacy and security	< 0.001*
Be agile and flexible in order to adapt their opinions quickly	< 0.001*
Embrace change and view failure as an opportunity for growth	< 0.001*
Encourage curiosity and creativity to promote innovation	< 0.001*
Embrace continuous learning for themselves and their teams	< 0.001*
Empower their teams to make data-driven decisions	< 0.001*
Identify and recruit people who have skills for current and future work opportunities	< 0.001*
Proactively nurture talented people to retain and motivate them	< 0.001*
Create a culture of teamwork and engagement that celebrates group success	< 0.001*
Improve collaboration by facilitating remote work/virtual teamwork	< 0.001*
Model clear two-way communication with stakeholders and employees	< 0.001*
Share a well-defined strategic vision to get stakeholders to buy in	< 0.001*
Talk about what success looks like and the roadmap to get there	< 0.001*
Use active listening and encourage others to do the same	< 0.001*
Have a continuous learning mindset	< 0.001*
Have self-leading ability	< 0.001*
Can fulfil collaboration/ownership/commitment requirements	< 0.001*
Demonstrate strong business acumen	< 0.001*
Show concern and care toward employees	< 0.001*
Demonstrate knowledge of value creation	< 0.001*
Adopt a solution-based approach	< 0.001*
Practice digital knowledge sharing	< 0.001*

Adopt a complexity leadership approach	< 0.001*
Adopt digital tools and support ongoing digital learning	< 0.001*
Demonstrate digital technical skills and big data understanding	< 0.001*
Possess digital technical skills and domain know-how	< 0.001*
Practice active listening when using digital tools	< 0.001*
Cultivate an inclusive culture with effective working relationships	< 0.001*
Encourage creativity and innovation	< 0.001*
Demonstrate effective communication skills	< 0.001*
Encourage continuous improvement and lifelong learning	< 0.001*
Adopt a relationship-based approach	< 0.001*
Adapt to constant change in the digital world	< 0.001*
Demonstrate ability in change management	< 0.001*
Demonstrate self-awareness	< 0.001*
Use digital processes to attract customers	< 0.001*
Use digital processes to get a competitive edge	< 0.001*
Demonstrate systemic thinking	< 0.001*
Take calculated digital risks to foster an experimental atmosphere	< 0.001*
Demonstrate market and business intelligence	< 0.001*
Demonstrate effective networking skills	< 0.001*
Demonstrate social dynamic understanding	< 0.001*
Have clear external focus in terms of customers' expectations/wishes	< 0.001*
Understand the potential risks associated with digitalization	< 0.001*

*$p < 0.001$

4.2. Percentages of Agreement

To gain an overall view of teachers' perceptions of the cruciality of digital leadership, percentages of "highly crucial" and "crucial" on each item were collapsed, for example, for Item 1, the total percentage of highly crucial/crucial was 91.1 percent (57.8 + 33.3). Findings showed that 90.3 to 91.2 percent of teachers perceived that it was highly crucial/crucial for principals to (1) adopt a solution-based approach, (2) stay up-to-date on the latest technological tools and trends, and (3) demonstrate knowledge of value creation. Additionally, 42 of the items had 81.4 to 89.2 percent of teachers who perceived that it was highly crucial/crucial for principals demonstrate the characteristics and attributes of digital leadership (see Table 4).

Table 4: Percentages of Agreement on Perceived Cruciality of Digital Leadership

It is crucial for principals to	1	2	3	4	5	4+5
Stay up-to-date on the latest technological tools and trends	0.0%	2.0%	6.9%	57.8%	33.3%	91.1%
Evaluate the impact of new technologies on their organizations	0.0%	1.0%	12.7%	58.8%	27.5%	86.3%
Use data for effective decision-making	1.0%	2.9%	10.8%	57.8%	27.5%	85.3%
Assess and manage risks related to data privacy and security	2.0%	0.0%	17.6%	52.0%	28.4%	80.4%
Be agile and flexible in order to adapt their opinions quickly	2.0%	2.9%	10.8%	57.8%	26.5%	84.3%
Embrace change and view failure as an opportunity for growth	0.0%	2.9%	11.8%	52.0%	33.3%	85.3%
Empower their teams to make data-driven decisions	0.0%	1.0%	17.6%	45.1%	36.3%	81.4%

Identify and recruit people who have skills for current and future work opportunities	1.0%	1.0%	11.8%	47.1%	39.2%	86.3%
Proactively nurture talented people to retain and motivate them	1.0%	1.0%	12.7%	44.1%	41.2%	85.3%
Create a culture of teamwork and engagement that celebrates group success	0.0%	2.0%	10.8%	52.0%	35.3%	87.3%
Improve collaboration by facilitating remote work/virtual teamwork	1.0%	4.9%	11.8%	42.2%	40.2%	82.4%
Model clear two-way communication with stakeholders and employees	0.0%	0.0%	16.7%	50.0%	33.3%	83.3%
Share a well-defined strategic vision to get stakeholders to buy in	0.0%	2.0%	11.8%	55.9%	30.4%	86.3%
Talk about what success looks like and the roadmap to get there	0.0%	2.0%	8.8%	63.7%	25.5%	89.2%
Use active listening and encourage others to do the same	1.0%	2.0%	9.8%	45.1%	42.2%	87.3%
Have a continuous learning mindset	2.0%	1.0%	7.8%	46.1%	43.1%	89.2%
Have self-leading ability	2.0%	1.0%	14.7%	48.0%	34.3%	82.3%
Can fulfil collaboration/ownership/commitment requirements	2.0%	1.0%	9.8%	49.0%	38.2%	87.2%
Demonstrate strong business acumen	1.0%	2.9%	14.7%	52.0%	29.4%	81.4%
Show concern and care toward employees	0.0%	1.0%	7.8%	53.9%	37.3%	91.2%
Demonstrate knowledge of value creation	0.0%	0.0%	9.8%	52.0%	38.2%	90.2%
Adopt a solution-based approach	0.0%	2.0%	12.7%	54.9%	30.4%	85.3%
Practice digital knowledge sharing	1.0%	0.0%	16.7%	46.1%	36.3%	82.4%
Adopt a complexity leadership approach	1.0%	2.9%	12.7%	51.0%	32.4%	83.4%
Adopt digital tools and support ongoing digital learning	2.0%	1.0%	14.7%	48.0%	34.3%	82.3%
Demonstrate digital technical skills and big data understanding	2.0%	2.0%	13.7%	52.0%	30.4%	82.4%
Possess digital technical skills and domain know-how 76.5	0.0%	2.9%	20.6%	49.0%	27.5%	76.5%
Practice active listening when using digital tools	0.0%	1.0%	20.6%	39.2%	39.2%	78.4%
Cultivate an inclusive culture with effective working relationships	0.0%	2.0%	10.8%	47.1%	40.2%	87.3%
Encourage creativity and innovation	0.0%	2.0%	8.8%	48.0%	41.2%	89.2%
Demonstrate effective communication skills	0.0%	3.9%	9.8%	42.2%	44.1%	86.3%
Adapt to constant change in the digital world	1.0%	2.0%	14.7%	54.9%	27.5%	82.4%
Demonstrate ability in change management	0.0%	2.0%	16.7%	46.1%	35.3%	81.4%
Demonstrate self-awareness	2.9%	0.0%	13.7%	52.0%	31.4%	83.4%
Use digital processes to attract customers	1.0%	2.9%	16.7%	39.2%	40.2%	79.4%
Use digital processes to get a competitive edge	0.0%	3.9%	12.7%	51.0%	32.4%	83.4%
Demonstrate systemic thinking	0.0%	2.9%	16.7%	46.1%	34.3%	80.4&
Take calculated digital risks to foster an experimental atmosphere	1.0%	2.9%	15.7%	52.0%	28.4%	76.8%
Demonstrate market and business intelligence	0.0%	2.9%	9.8%	53.9%	33.3%	87.2%

Demonstrate effective networking skills	2.9%	1.0%	12.7%	49.0%	34.3%	83.3%
Demonstrate social dynamic understanding	2.0%	1.0%	16.7%	48.0%	32.4%	80.3%
Have clear external focus in terms of customers' expectations/wishes	0.0%	2.9%	20.6%	50.0%	26.5%	76.5%
Understand the potential risks associated with digitalization	1.0%	2.0%	17.6%	48.0%	31.4%	79.4%

Not crucial at all = 1, Not crucial = 2, Neutral = 3, Crucial = 4, Highly crucial = 5

5. Implications and Recommendations

5.1. Implications

Results imply that an overwhelming majority of teachers tend to regard digital leadership among principals as very crucial/crucial, indicating that principals should (1) adopt a solution-based approach, (2) stay relevant on the latest technological tools and trends, and (3) demonstrate knowledge of value creation. Moreover, a preponderance of teachers (81.4 to 89.2 percent) also tends to perceive that it is highly crucial/crucial for principals demonstrate the characteristics and attributes of digital leadership as reflected by more than 40 items. Current findings were supported by previous research, which revealed that digital skills among principals tend to range from moderate to high levels. Hamzah, Juraime, and Mansor (2016) found that Malaysian principals tend to practice technology leadership at a very high level, while being very competent at managing the school curriculum. Similarly, Omar, Ismail, and Kasim (2019) revealed that the level of principals' technology leadership tends to be high. Besides, Yusof, Yaakob, and Ibrahim (2019), who identified the functions and behaviors of the digital leadership among school principals, found two dimensions, nine functions, and 42 behaviors in relation to digital leadership among principals. The two dimensions are communication and school climate, while the nine functions include virtual meetings, virtual discussions, virtual information sharing, online file sharing, virtual communication, virtual teaching and learning supervision, virtual monitoring of students' performance, virtual promotion of development and professionalism and virtual promotion of school's goals.

On the other hand, Ramalingam et al. (2022) found that that Malaysian principals' level of competence in technology management tends to be at a moderate level, asserting that school administrators need to be fully committed to using digital technology to enhance efficiency and productivity in school management. Similarly, Abdullah and Abdul Kadir (2023) found a significant positive relationship tends to exist between the principals' digital leadership and the teachers' digital competency at a moderate level, implying that Ministry of Education should provide more training in digital leadership to better equip principals as school administrators. Lastly, a recent study by Goh and Mansor (2024) indicated that the overall level of digital leadership among Malaysian school leaders tends to be high, which allows them to demonstrate more efficient organizational management, while stiving to drive positive change and innovation in the digital era.

5.2. Recommendations

In light of the findings, several recommendations were made to reinforce the digital leadership skills among principals in Sabah. Sheninger (2022) reiterated that effective digital leaders often focus on effective communication, branding, and student engagement. First, principals in Sabah need to provide stakeholders with relevant information in real time through various free social media tools and strategies to interact with stakeholders in two-way communication. Second, they need to become storytellers-

in-chief who maintain a positive public relations platform by effectively managing digital content by which they share positive news related to their school in a transparent manner. Third, they need to leverage social media to create a positive brand presence that emphasizes the positive aspects of the school culture, increases community pride, and helps to attract/retain students. Fourth, to see increases in cognitive, affective, and psychomotor achievement among students, they need to use digital tools and processes to reflect real life learning that allows students to apply what they have learned in class and online.

Sheninger (2022) added that effective digital leaders focus on digital growth and development, re-envision learning spaces and environments, and digital opportunities among students. First, principals in Sabah need to provide students with real-world tools that allow them to create learning outcomes that demonstrate conceptual mastery. They need to use various digital tools to enhance their essential skill sets, such as, communication, collaboration, creativity, media literacy, global connectedness, critical thinking, and problem solving. By letting students choose the appropriate digital tools, they can foster a greater appreciation for learning and development, while better preparing them for the real world. Second, they need to form their own personal learning network to meet the diverse learning needs of students, and to acquire resources, access knowledge, and receive feedback by connecting with educational experts and practitioners. Third, to re-envision learning spaces and environments, they need to use digital resources to initiate sustainable change, and subsequently, transform learning spaces and environments that support essential skill sets that are aligned with the real world. They need to establish a vision and strategic plan to create a school that is dedicated to learning in a highly digitalized world. Fourth, they need to increase opportunities for digitalization by using digital tools to improve existing programs, resources, and professional development. As catalysts for change, they need to leverage connections through digital technology to make improvements across multiple areas of the school culture.

Ridho et al. (2023) reiterated that digital leadership can be realized if principals continue to strive and provide opportunities for all staff to come into direct contact with digital technology, particularly in terms of the 4Cs, namely, critical thinking, creativity, communication, and collaboration. First, principals in Sabah should have the ability to think critically to find innovative solutions to current problems. Second, in terms of creativity, they should show the ability to innovate new things that can keep up with the times. Third, they are expected to be highly communicative in relaying information that is easily understood by staff. Lastly, to effectively implement the three formulas, principals should be able to interact and collaborate with stakeholders who can help promote quality education. Further, to actualize digital leadership, they need to find the space and opportunities to bring about changes to the school culture, which requires a combination of mindsets, behaviors, and skills needed implement innovative technology platforms to keep abreast with the demands of the digital revolution. For example, they need to influence, encourage, and motivate staff to integrate the use of technology into all school activities by maintaining effective communication and assuming various roles and situations to achieve the digital goals of their school.

Ridho et al. (2023) added that, in the current era of technological disruption, principals need to display the basic characteristics of digital leadership. First, principals in Sabah not only should demonstrate innovative vision, but they must also possess networking intelligence and digital talent scout capabilities. Second, they should provide motivation

and become a role model for staff by ensuring that they have direct contact with digital technology. Third, they should be able to make strategic transformations and willing to learn by trial and error, besides acting as knowledge oriented, lifelong learners. These characteristics enable them to practice digital leadership in every educational unit, especially in improving quality education. Overall, they need to have a strategy to make digital leadership a success, which requires them to provide quality infrastructure, which focus on the role of digital leadership in the organization, staff training and development, specific learning objectives, and program evaluation. Lastly, principals should implement their digital leadership strategies in a transparent manner, especially in terms of funding, procurement of digital equipment, and suggestions from various parties. They should also display the readiness to adapt to any adjustments by increasing their sensitivity to existing digital information and updates based on accurate and relevant data.

Sharma (2023) recommended several best practices that educators can adopt for navigating the ever-changing world of digital technology to prepare student, staff, and other stakeholders to seamlessly integrate it into their lives. First, principals in Sabah should build a vision for digital transformation that considers the school's geographical location, resources, and budget; it should involve collaborating with stakeholders, understanding of educational goals, and alignment of digital initiatives to support educational goals. By establishing a clear vision, they can inspire staff and lay the foundation for successful digital transformation. Second, principals should create a digital integration plan that serves as a roadmap for implementing digital technology in the school. They need to provide access to the existing infrastructure, identify relevant tools and resources, and develop strategies to ensure seamless integration. With a well-designed plan, they can empower staff to effectively leverage digital technology for enhanced teaching and learning. Moreover, they should also manage change by communicating the "what" and "why" to ensure the success of the integration plan. Their effective change management will lead to appropriate adoption and utilization of new digital tools by teachers, students, and parents.

Sharma (2023) added that principals should emphasize professional development to increase teachers' interest and self-efficacy in using digital technology. Moreover, by equipping teachers, students, and other users with the necessary digital skills and knowledge, they can also foster a culture of continuous learning, thus empowering various parties to explore the innovative ways to apply digital technology. Additionally, principals need to effectively manage infrastructure and resources to support digital initiatives. They need to maintain robust networks, manage hardware and software, and stay informed about emerging technologies. By effectively managing resources, they can provide a reliable and secure digital environment for teachers and students, which comprises strong technical support to resolve technical issues. Lastly, principals need to address data privacy and security concerns to build trust and confidence among parents, students, and staff. They should establish data privacy policies, implement security measures, and educate the school community about the responsible use of digital technology, while also considering the school's geographical location to create policies in accordance with local laws.

According to Murray (2024), to demonstrate effective digital leadership, school leaders need to foster a culture of innovation and risk taking, cultivate digital teacher leadership, utilize technology for improved communication, and communicate their own learning. First, principals in Sabah need to build a school culture based on trust and a safe environment for staff to learn, grow, and push the digital envelope. Second, they need to

allow staff to assume leadership roles rather than micromanaging their every move. They can promote positive digital outcomes by abdicating some control and allowing staff to lead, mentor, and inspire their colleagues. Third, they need to make the flow of information meaningful and relevant for all stakeholders by utilizing social media outlets to provide real-time information, grade reporting, and attendance information. Further, they should plug into networks and learning communities via Twitter, Google Plus, and other social forums, where professional growth can occur at any time. Fourth, they need to promote team growth and continuous improvement by being transparent in their own professional growth; they should share their personal experiences and reflective thoughts, while uploading resources from their learning network, and encouraging staff to do the same.

Murray (2024) added that effective digital leaders should invigorate team meetings, power down to maintain sanity, utilize technology for improved efficiency, and model expectations for staff. First, principals in Sabah not only should use technology to involve a large group of staff, but also make their meetings interactive, efficient, and meaningful. They need to use back channels to provide an avenue of engagement and real-time interaction, as well as survey tools to obtain staff feedback and thoughts in real time. Second, they need to allocate time to disconnect and recharge, rather than engaging in constant and continuous connectivity; they should try to spend quality time with family and friends, which allows them to remain at peak performance while online. Third, they need to constantly find ways to improve efficiency by automating as many tasks as possible, while using electronic data processing and other digital resources to replace manual work. Fourth, they need to adopt the "do as I do" approach to clarify their expectations by expecting staff to practice what they emphasize. By modelling their expectations, and leading by example and with integrity, they can help foster an innovative environment that enhances lifelong learning and meaningful technology infusion among staff.

To bridge the gap between leadership and digital technology, more digital leadership excellence (DLE) programs should be implemented to navigate the tech frontier. By emphasizing continuous learning, leadership, and innovation to create a more inclusive, sustainable, and technologically-empowered future for Malaysia. By empowering leaders from the government, private sector, and academia with the fundamental skills and knowledge to redefine public service delivery and strengthen industries, such initiatives help strengthen Malaysia's global competitiveness, while advancing inclusive and sustainable growth. DLE programs help equip leaders with the knowledge and tools to spearhead digital transformation within their organizations and improve operational efficiencies. It usually encompasses intensive hybrid training that covers key domains such as 5G, Artificial Intelligence (AI), the Internet of Things (IoT), Cloud Computing, Big Data, Green Technology, and Cybersecurity. Additionally, DLE programs should also offer industrial visits to global leading tech companies that enable leaders to gain deeper insight into emerging technologies, while participating in capstone projects that address the digital challenges in Malaysia, which include (1) exploring technology-driven solutions for smarter, safer, and more efficient public mobility, (2) outlining strategies to upskill Malaysia's workforce and nurture digital expertise, (3) enhancing digital adoption among small and medium enterprises to future-proof their operations, and (4) reimagining public service delivery with integrated, user-centric digital platforms (Huawei Malaysia, 2025).

To conclude, this study has generated deeper insight into principals' digital leadership in Malaysia, which tends to be at a high level. Nevertheless, generalizability of findings can be increased by using larger, randomized samples of teachers from other locations. Moreover, future research should also include the perceptions of school administrators and non-teaching staff to gain a more balanced view with regards to digital leadership.

Ethics Approval and Consent to Participate

This study has strictly adhered to all ethical procedures involving the use of human subjects. Informed consent was obtained from all respondents who were ascertained of their anonymity, with their responses kept strictly private and confidential. Moreover, the data would be de-identified and securely stored in a strong room. Lastly, respondents were also informed that the study was of low risk and that they could stop participating any time without any repercussions.

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Conflict of Interest

The authors report no potential conflict of interest regarding this study in terms of the research, authorship, or publication of this article.

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