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MAPPING STAGES OF CONCERN AMONG SARAWAK TEACHERS USING CBAM: THE ROLE OF DIGITAL COMPETENCY AND SCHOOL LOCATION

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Abstract:

This study investigates the stages of concern (SoC) among urban and rural public school teachers in Sarawak regarding the adoption of emerging technologies in their instructional practices. Guided by the Concerns-Based Adoption Model (CBAM), a quantitative approach was employed involving 380 teachers who completed the Stages of Concern Questionnaire (SoCQ). Univariate ANOVA analyses were conducted to examine the effects of School Location (SL) and Digital Competency Score (DCS) on the seven SoC dimensions. The results revealed significant differences ($p < .01$), indicating that both school location and digital competency significantly influence teachers' emerging technologies adoption. These findings suggest the need for structured digital competency training tailored to teachers' specific SoC stages based on geographical location and digital competency levels.

Keywords:

Digital Divide, Emerging Technologies Adoption, Stages of Concerns, Concerns-Based Adoption Model, Digital Competency Score

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Introduction

The rapid development of emerging technologies has significantly transformed educational practices, affecting the integration of digital tools into pedagogical methodologies. Variations in technology adoption persist across educational contexts, with teacher concerns and readiness levels varying as a function of multiple factors, including institutional environment and digital proficiency. Systematic analysis of these factors is critical for designing targeted professional development initiatives that align with educators' specific requirements and contextual challenges.

The Concerns-Based Adoption Model (CBAM) offers a theoretical framework to analyse educators' Stages of Concern (SoC) during technology adoption. This model delineates seven sequential stages, progressing from limited awareness and self-oriented concerns to broader considerations about technology's pedagogical efficacy. By identifying teachers' positions along this continuum, researchers and policymakers can more effectively discern barriers to and facilitators of technology integration across diverse institutional settings.

In the Malaysian context, disparities observed between urban and rural educational institutions—including infrastructure quality, resource accessibility, and professional development opportunities—may result in divergent patterns of technology adoption. Urban educators frequently benefit from greater technological exposure, reliable connectivity, and structured training programs, whereas rural counterparts often encounter constraints such as limited digital infrastructure, insufficient technical support, and lower baseline competency levels. Such systemic inequities may differentially influence educators' SoC and their capacity to implement emerging technologies.

Recognising the critical role of teachers in bridging this digital divide, the Ministry of Education (MOE) has mandated the Digital Competency Assessment to evaluate teachers' readiness for technology integration and adoption (MOE, 2024). This assessment generates DCS, categorising teachers into Basic, Intermediate, or Advanced levels based on their proficiency in utilising digital tools for teaching. While teachers with an Advanced DCS demonstrate a greater ability to integrate emerging technologies into their instructional practices, those at the Basic level may struggle with even fundamental digital applications. However, DCS alone may not provide a complete picture of teachers' actual engagement with technology in the classroom. External factors such as infrastructure availability, teachers' emerging technology adoption concerns, academic qualifications and access to professional development significantly influence teachers' ability to effectively integrate digital tools, raising questions about the extent to which DCS reflects real-world emerging technology adoption.

Problem Statement

To better understand how teachers engage with emerging technologies, it is crucial to examine their concerns and competencies about emerging technologies adoption particularly in urban and rural settings. The Stages of Concern framework, part of the CBAM provides insights into how teachers progress from initial awareness to full implementation of new technologies. This study aims to analyse the differences in teachers' concerns regarding emerging technology adoption in urban and rural Sarawak schools and explore whether DCS levels influence these concerns. By examining these dynamics, this study seeks to inform the development of targeted professional development programs and policies that will empower educators, bridge the

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digital divide, and enhance emerging technology adoption in classrooms across diverse educational settings.

This study aims to investigate the differences in teachers' concerns regarding emerging technologies adoption in rural and urban schools in Sarawak. The specific objectives are:

i. To differentiate the SoC about emerging technologies adoption between urban and rural teachers in Sarawak.
ii. To investigate whether DCS affect teachers' SOC about emerging technologies adoption.

Literature Review

One of the main challenges that the digital divide in Sarawak represents is the need to focus on urban versus rural schools. As urban schools have better internet access and infrastructure to incorporate digital devices in the learning process, rural schools' access to the internet is inconsistent, and their infrastructure is usually outdated, which can result in a poorer digital learning process. This also relates to the differences in socioeconomic status, as students might have better access to personal digital devices in urban schools, while their rural counterparts may have less access. Therefore, it is important to analyse how these factors affect the learning process, as they can impact not only students' learning but the way the technology can be integrated into the learning process by teachers.

Disparities in Digital Infrastructure

Through the digital infrastructure inequalities analysis, the difference in facilities between rural and urban schools in Sarawak is significant. Urban schools have better facilities in the form of technology, internet access, websites, etc., which allow them to have a better learning process online and offline. In contrast, rural schools do not have enough facilities, whether technological needs or unreliable internet access. As a result, when they need to access web-based learning resources, both students and teachers experience difficulties (Yap et al., 2020). Digital learning can be ineffective in rural schools because the accessibility of technology is very limited due to these infrastructural issues. Therefore, rural students and teachers are not able to maximise the benefits of technology and the internet for learning purposes (Horn & Gifford, 2022).

In addition, outdated infrastructure and low internet connections also serve as barriers for rural schools in Sarawak. The statistics show that the broadband coverage rate in Sarawak is only at 107 per 100 people (Yap et al., 2020). The low internet penetration level gives rise to further negative implications as there will not be enough online learning resources coming in, and schools may not be able to sustain their use of learning apps and tools after the whole pandemic situation. The learning gap causes students in the rural areas to lose their connection with the latest learning systems and technologies, widening the digital gap between the different areas of these schools. In the long run, systematic investment and policies will have to be planned to overcome this critical barrier due to structural weaknesses that pose impact on educational developments in Sarawak.

Furthermore, another dimension of the digital divide is affected by socioeconomic factors in Sarawak where students' access to the availability of personal digital devices. Due to the socioeconomic status, families from rural areas are unable to buy the devices needed for

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students to participate fully in a digital learning environment. Previous findings suggest that the limited availability of reasonably priced internet-enabled devices in the rural community is a major constrain in the socioeconomic development (Horn & Gifford, 2022). The socioeconomic divides create an imbalance in students' learning experiences where rural students suffer from lesser access to hardware components to fully engage in a digital learning environment compared to their upper-class counterparts in urban areas. Hence, to bridge the socioeconomic divide, it is vital to improve students' access to personal digital devices to provide more learning opportunities for students and can potentially reshape the educational landscape in the state.

Socioeconomic Influences on Access

Disparities in device ownership and internet connectivity in Sarawak are significantly influenced by socioeconomic factors. In rural areas, the financial constraints faced by many families severely limit the acquisition of necessary digital devices, creating a prominent barrier to accessing equitable educational opportunities. According to research, this lack of affordability in rural communities restricts children's participation in digital learning environments (Horn & Gifford, 2022). Moreover, the limited availability of reliable internet further exacerbates these educational inequities, as it curtails the ability of students to engage with digital resources consistently. This socioeconomically driven digital divide not only hampers the development of digital literacy among students in rural Sarawak but also perpetuates existing educational disparities, necessitating focused policy measures to enhance digital infrastructure and device accessibility in these underserved regions.

As a result, the socioeconomic disparities in Sarawak deeply influence students' learning experiences and educational outcomes. Students in rural areas, limited by financial constraints, often face barriers in accessing digital devices and reliable internet, which are essential for engaging with digital learning platforms. This lack of resources affects their ability to participate in digital classrooms, thus widening the educational gap between urban and rural students (Horn & Gifford, 2022). The absence of adequate digital tools not only hampers students' current learning experiences but also limits their future educational opportunities, as they are less exposed to digital literacy skills that are increasingly vital in today's knowledge economy. Consequently, addressing these socioeconomic barriers is imperative for ensuring that all students, regardless of geographical location, can achieve equitable learning outcomes and are better prepared for digital integration in their future endeavors (Vong & Then, 2019).

Integration of Emerging Technologies in Malaysian Schools

Emerging technologies in education refer to innovative and transformative tools and methodologies that significantly impact teaching and learning practices. According to Crompton and colleagues, these technologies include digital, electronic, and computational advancements that facilitate novel approaches to educational challenges (Crompton et al., 2020). They are characterised by their ability to bring about change in educational settings by enhancing motivation, engagement, and accessibility for learners. Moreover, emerging technologies are not only about facilitating new types of learning experiences but also about redefining how knowledge is delivered and consumed in classrooms (Crompton et al., 2020). As these technologies evolve, they continue to shape the educational landscape, pushing the boundaries of traditional learning environments and fostering the development of future-ready skills.

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The national ICT policy initiatives in Malaysia, such as the Smart Schools programme, have demonstrated varying degrees of success and face several challenges in implementation. According to Hanafi et al. (2024), these initiatives aim to modernise educational practices and prepare students for the demands of the digital age, yet they encounter obstacles related to infrastructure and resource allocation. Ramalingam & Maniam (2024) further elaborate on how the successful integration of these policies is often hindered by inconsistent policy application and insufficient training for educators, which can affect overall effectiveness. Moreover, despite the progressive intentions, the Smart Schools programme has faced critique for its uneven execution across different regions, highlighting disparities in access to technological resources (Ramalingam & Maniam, 2024). Consequently, while the foundational goals of these ICT policies are aligned with enhancing educational outcomes, their actual impact is contingent upon addressing these systemic challenges.

The advent of emerging technologies such as artificial intelligence (AI), augmented reality (AR), virtual reality (VR), mixed reality (MR) and many other emerging technologies in education signified a transformative shift towards more adaptive and personalised learning experiences, responding to the demands of the Industrial Revolution 4.0 (Cheok et al., 2017). In Malaysian schools, AI has the potential to revolutionise educational practices by enabling real-time feedback and personalied learning pathways, although its implementation faces several challenges. Through adaptive learning technologies, AI can tailor educational content to meet the individual needs of students, thereby enhancing both engagement and learning outcomes (Ramalingam & Maniam, 2024). Schools are also integrating AI-driven chatbots to provide real-time assistance to students, streamlining information dissemination and support. Predictive analytics further aids educators by identifying students at risk of falling behind, allowing for timely interventions (Razak et al., 2025). However, teachers' perceptions of e-learning are mixed, with Ahmad et al. (2022) noting that while technology adoption can enhance learning, obstacles such as access to resources can impede widespread use. Factors influencing technology adoption highlight the need for comprehensive training and infrastructure development to ensure seamless integration of digital tools, particularly in science education where practical applications are pivotal (Cheok et al., 2017). Thus, addressing these barriers is essential not only for leveraging AI's full potential but also for ensuring equitable access to digital learning platforms across varying educational contexts in Malaysia.

The integration of Augmented Reality (AR) and Virtual Reality (VR) into Malaysian education has garnered attention due to their potential to revolutionise learning experiences. These innovative technologies are instrumental in enhancing Malay language writing skills by offering students a dynamic, engaging environment for practice and immersion (Chandran & Said, 2024; Sofiadin, 2023). Furthermore, AR and VR provide transformative opportunities in higher education by facilitating immersive experiences that enrich students' understanding of complex subjects, aligning with the broader objectives of Education 4.0 (Bonde, 2024). In technical and vocational education settings, these technologies play a crucial role in developing practical skills by simulating real-world scenarios, thus preparing students more thoroughly for the workforce (Sofiadin, 2023). Additionally, virtual reality (VR) tools are being implemented to allow students to explore historical sites, scientific concepts, and more within an immersive environment (Azar & Tan, 2020). Such technologies not only make learning more interactive but also cater to different learning styles, encouraging students to engage actively with the content being taught.

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Recent studies have highlighted the transformative impact of emerging technologies in educational settings, showcasing a variety of innovative applications that enhance learning outcomes. These applications are not only improving engagement and motivation among students but also equipping them with skills relevant to the demands of the modern workforce, thus fostering a robust and future-oriented educational framework. While the benefits of emerging technologies in education are numerous, it is crucial to consider the role of teachers in their adoption. Teachers are at the forefront of educational transformation, yet the shifting landscape towards emerging technologies may overshadow the importance of pedagogical expertise. The effective adoption of these technologies depends significantly on teachers' willingness and capability to adapt to new instructional tools. Therefore, while these technologies promise to revolutionise education, ensuring that teachers remain integral to the learning process is essential to leverage their full potential.

Teachers' SoC and Digital Competency in Emerging Technology Adoption

The role of digital competency in teachers' emerging technology adoption is pivotal, particularly when considering the variance between urban and rural educational settings. Urban teachers often exhibit higher DCS, reflecting their greater access to resources and training opportunities. In contrast, rural educators face challenges that impede their digital proficiency development, as highlighted by research in Malaysian educational contexts (Omar & Mohmad, 2023). The correlation between the SoC and DCS reveals significant impediments in integrating technology effectively, with rural educators requiring targeted interventions. Therefore, strengthening digital literacy through tailored professional development programs is essential, addressing inequities and fostering competence for effective technology integration in these disparate environments (Sulaiman & Halamy, 2021).

Teachers' SoC in emerging technology adoption represent a critical aspect of understanding how educators interact with digital tools, especially when contrasting urban and rural settings. These stages often reflect the varying levels of apprehension, awareness, and engagement that educators experience when integrating technology into their practice. Urban educators typically report advanced stages of concern, correlating with their higher digital competency levels due to better access to resources. Conversely, rural teachers frequently encounter initial SoC, attributable to limited exposure and training opportunities in digital environments. This distinction underscores the necessity for differentiated support strategies to address these disparities in emerging technology adoption across diverse educational contexts.

The SoC framework provides insights into the varying degrees of apprehension and engagement that teachers experience regarding emerging technology adoption. In examining this framework, studies have revealed distinct differences between urban and rural educators, with notable variations evident in the Malaysian context, particularly in Sarawak. Rural educators typically encounter initial stages, focusing on informational and personal concerns due to limited exposure and lack of resources, which impedes their emerging technology adoption process (Sulaiman & Halamy, 2021). Conversely, urban teachers tend to reach more advanced stages involving consequence and collaboration concerns, facilitated by better access to digital tools and professional development programs (Omar & Mohmad, 2023). Moreover, cross-analysis between these stages and DCS in the region remains scarce, representing a critical gap in the literature that warrants further investigation to enhance understanding and support tailored interventions.

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Furthermore, examining the relationship between SoC and DCS reveals a notable disparity between urban and rural educators in Malaysia, particularly within the context of Sarawak. Urban teachers usually possess higher digital competency, facilitated by access to extensive resources and continual professional development opportunities, leading them to progress to more complex stages of concern (Omar & Mohmad, 2023). In contrast, rural educators often demonstrate lower DCS, correlating with their initial SoC stages, as limited resources and training hinder their technological integration capabilities (Sulaiman & Halamy, 2021). This significant variation underscores the necessity for differential support strategies, emphasising the tailored development programs that can address these discrepancies in digital proficiency. Addressing this gap through localised interventions could significantly enhance rural teachers' digital competencies, ultimately advancing equitable education standards and emerging technology adoption across diverse educational landscapes in Malaysia.

Moreover, the current literature reveals a critical gap in research concerning the cross-analysis between SoC and DCS, particularly within the Malaysian educational context. Despite the evident disparities in digital competency and concern stages between urban and rural teachers, studies fail to extensively explore how these elements interact, which limits the understanding of educational emerging technology adoption (Razak et al., 2023). This deficiency highlights the necessity for comprehensive research initiatives exploring how DCS influences SoC progression among educators in varying settings. Bridging this knowledge gap through targeted studies could facilitate the development of effective interventions aimed at promoting equitable digital proficiency, especially in under-resourced areas (Lan et al., 2024). Consequently, addressing this research void is essential for advancing the understanding of emerging technology adoption processes and promoting systemic improvements across educational frameworks.

Navigating the intricacies of correlating SoC and DCS presents distinct challenges, primarily due to the diverse educational environments in which teachers operate. This diversity complicates the uniform application of strategies tailored to specific SoC and DCS intersections, particularly in regions like Sarawak, where educational settings vary considerably (Omar & Mohmad, 2023). Rural educators, often limited by resources, might not experience the same progression through SoC as their urban counterparts, thus requiring alternative approaches to study and address their needs effectively (Sulaiman & Halamy, 2021). Emphasising the necessity for longitudinal studies, existing literature suggests that monitoring these changes over time is imperative to gain a comprehensive understanding of how SoC and DCS evolve in tandem, aiding in the design of tailored interventions (Razak et al., 2023). Ultimately, addressing these challenges could pave the way for balanced advancements in digital competency, particularly in educationally diverse regions like Malaysia.

Methodology

Instrument

SoC is measured using the SoC Questionnaire (SoCQ), which is an eight-point Likert scale with 35 questions in the survey that can be used in any educational setting to determine the SoCQ profile of an individual undertaking an innovation (Hall and Hord, 1987). All statements in this questionnaire were rated on an eight-point scale (0-7) which ranges from "not true of

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me now" (0) to "very true of me" (7). This SoC profile makes it possible for the implementer of an innovation to address the concerns of the faculty to support the adoption of change.

Each statement expresses concern about a particular innovation. There were five questions in each stage of concern. The items are not arranged according to each stage of concern but are presented in a mixed sequence. Table 1 below shows the questions belonging to each stage. Additionally, five open-ended questions were asked to gather further details related to the change process. In this study, the scores of 35 SoCQ were recoded using SPSS Ver 26 into seven SoC based on school location.

Table 1: Statements On The Stages Of Concern Questionnaire Arranged According To Stage

Stage of Concerns		Item in the SoCQ
Impact	Stage 6- Refocusing	2, 9, 20, 22, 31
	Stage 5- Collaboration	5, 10, 18, 27, 29
	Stage 4- Consequence	1, 11, 19, 24, 32
Task	Stage 3- Management	4, 8, 16, 25, 34
Self	Stage 2- Personal	7, 13, 17, 28, 33
	Stage 1- Informational	6,14, 15, 26, 35
Unrelated/ Unconcerned	Stage 0- Awareness	3, 12, 21, 23, 30

(Source: Adapted from George et al., 2006: pp 27-28)

These seven stages (Awareness, Informational, Personal, Management, Consequence, Collaboration, and Refocusing) are organised into four broad categories: Unrelated/ Unconcerned, Self, Task, and Impact, as delineated by Hall, George, & Rutherford (1979) as shown in Table 3.2. The progression of these concerns is logical, advancing in sequence from unrelated concerns to self-focused concerns, then to task-related issues, and finally to impact-based considerations. These categorisations provide a framework to understand varying levels of concern and engagement with the change process, enabling organisations to tailor support and interventions based on individuals' specific problems.

Population and Sample

The population of this study consists of teachers working in the public schools in Sarawak, registered under the Malaysia Ministry of Education (MOE). According to the Education Statistics produced by the MOE, in 2020 there were 45,640 teachers and 1,458 public schools in Sarawak. Based on data provided by MOE and according to Krejcie and Morgan (1970), a total of 380 teachers had been chosen to participate in this study. The teachers were selected from this population by using a non-probability and convenient sampling approach. For this study, an online SoC Questionnaire (SoCQ) was distributed to all teachers with an invitation to take part in the study. The sample consisted of teachers from urban (n=173) and rural (n=207) schools across Sarawak. The teachers showed varying level of DCS (Table 2).

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Table 2: Distribution of Schools' Location and Digital Competency Score

Category	Participants	Frequency	Percentage (%)
SL	Urban	173	45.5
	Rural	207	54.5
DCS	Basic	61	16.1
	Intermediate	227	59.7
	Advance	92	24.2

Data Collection and Analysis

To investigate the influence of SL (urban and rural) and DCS (beginner, intermediate and advanced) on teachers' SoC regarding emerging technology adoption, data were gathered through Stages of Concern Questionnaire (SoCQ), a theoretically grounded instrument developed by Hall and Hord (1987) and widely employed in educational change research. The questionnaire targeted seven SoC dimensions namely, Awareness, Informational, Personal, Management, Consequence, Collaboration and Refocusing. A non-probability convenient sampling approach was employed to select participants enabling the inclusion of teachers from diverse school settings across Sarawak who were readily accessible through institutional email networks and professional contacts. This sampling method is frequently adopted in education research when probabilistic selection is impractical due to contextual constraints (Creswell & Creswell, 2018; Etikan, Musa, & Alkassim, 2016). Although less generalisable than probabilistic methods, it allowed timely and pragmatic access to a substantial teacher cohort for comparative analysis of contextual variables influencing technology adoption. Furthermore, this sampling method ensures procedural reliability despite sampling limitations (Etikan, Musa, & Alkassim, 2016)

Following data collection, descriptive statistics were computed using IBM SPSS Statistics Version 26, including mean scores and standard deviations for each SoC stage. Percentile values were derived from raw scores using the CBAM's Percentile Conversion Chart (George, Hall, & Stiegelbauer, 2006), providing standardised concern profiles. These descriptive metrics facilitated preliminary insights into variations in SoC patterns across different educational settings and competency levels. Prior to conducting inferential tests, statistical validity was addressed through assumption testing for normality, homogeneity of variance and independence. The Kolmogorov-Smirnov test yielded a non-significant result ($p > .05$) and therefore satisfied the assumption of normality. Levene's test for homogeneity of variance returned a non-significant result ($p > .05$), confirming that the variance across groups was sufficiently equal to satisfy the assumption required for parametric analysis.

Subsequently, univariate ANOVA was applied to assess both the main effects of school location and DCS, as well as their interaction effects (SL × DCS) on each SoC dimension. Reliability in this study was established through both procedural and instrument-level rigor. An alpha level of $p < .05$ was used as the threshold for statistical significance. For each dependent variable, F-values, degrees of freedom, p-values, and partial eta squared (η^2) were reported to quantify the strength and practical relevance of observed effects. Multiple comparisons were controlled using the Bonferroni correction to reduce the likelihood of Type I errors (Tabachnick & Fidell, 2019). This rigorous analytical process enabled a nuanced understanding of how geographical location and competency-based factors shape teachers'

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engagement with emerging technologies, offering evidence-based direction for contextualised professional development interventions (Creswell & Creswell, 2018).

Results
The purpose of the univariate ANOVA was to assess the individual and interactive effects of school location (urban and rural) and Digital Competency Score (DCS: beginner, intermediate, and advanced) on multiple dependent variables representing different stages of concern regarding the adoption of emerging technology. These stages include Awareness, Informational, Personal, Management, Consequence, Collaboration, and Refocusing. Table 3 shows the summary of univariate ANOVA for the effects of SL and DCS on Stages of Concern.

Table 3: Summary of Univariate ANOVA for the Effects of School's Location (SL) and Digital Competency Score (DCS) on Stages of Concern

Dependent Variable	Source	F	df	p	Effect Size (η^2)
Awareness	SL	15.758	(1, 374)	< .001	.041
	DCS	10.282	(2, 374)	< .001	.052
	SL × DCS	3.511	(2, 374)	.031	.018
Informational	SL	28.529	(1, 374)	< .001	.071
	DCS	2.289	(2, 374)	.103	.012
	SL × DCS	11.047	(2, 374)	< .001	.056
Personal	SL	19.571	(1, 374)	< .001	.050
	DCS	7.558	(2, 374)	< .001	.039
	SL × DCS	11.599	(2, 374)	< .001	.058
Management	SL	17.997	(1, 374)	< .001	.046
	DCS	4.380	(2, 374)	.013	.023
	SL × DCS	3.140	(2, 374)	.044	.016
Consequence	SL	20.376	(1, 374)	< .001	.052
	DCS	25.532	(2, 374)	< .001	.120
	SL × DCS	13.806	(2, 374)	< .001	.069
Collaboration	SL	12.505	(1, 374)	< .001	.032
	DCS	8.635	(2, 374)	< .001	.044
	SL × DCS	11.696	(2, 374)	< .001	.059
Refocusing	SL	15.421	(1, 374)	< .001	.040
	DCS	7.315	(2, 374)	< .001	.038
	SL × DCS	6.564	(2, 374)	.002	.034

A series of univariate ANOVAs were conducted to examine the effects SL and DCS on the seven Stages of Concern regarding technology adoption. Main effects of SL were significant across all concern stages, with Informational concerns ($F(1, 374) = 28.529$, $p < .001$, $\eta^2 = .071$) showing the largest effect size.

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Main effects of DCS were significant for all stages except Informational concerns ($F(2, 374) = 2.289$, $p = .103$). The strongest effect was observed in Consequence concerns ($F(2, 374) = 25.532$, $p < .001$, $\eta^2 = .120$).

Interaction effects (SL × DCS) were significant for all concern stages, with Informational ($F(2, 374) = 11.047$, $p < .001$, $\eta^2 = .056$), Personal ($F(2, 374) = 11.599$, $p < .001$, $\eta^2 = .058$), Consequence ($F(2, 374) = 13.806$, $p < .001$, $\eta^2 = .069$), and Collaboration ($F(2, 374) = 11.696$, $p < .001$, $\eta^2 = .059$) showing the highest interaction effects. These results suggests that the SoC of emerging technologies adoption varies by school location and teachers' DCS particularly in the Informational, Personal, Consequence and Collaboration stages.

Effect of School Location (Urban vs. Rural)

The significant main effects of school location across all seven stages of concern suggest that teachers in urban and rural schools perceive technology adoption differently.Teachers in urban schools likely experience fewer barriers to technology adoption due to better infrastructure, internet access, and availability of professional development opportunities. Consequently, their concerns may be more focused on higher-order stages, such as Collaboration and Refocusing, where they seek ways to improve technology integration and refine their teaching strategies.

On the other hands, teachers in rural schools, on the other hand, may face greater logistical and resource-related challenges, such as unreliable internet access, limited technical support, and fewer professional development opportunities. These factors contribute to stronger concerns at the earlier stages of adoption, particularly Informational, Personal, and Management stages, where teachers are more focused on understanding how to use technology effectively and managing its implementation within their classrooms.

The largest effect of school location was found in the Informational stage ($F(1, 374) = 28.529$, $p < .001$, $\eta^2 = .071$), indicating that teachers in rural schools have significantly greater concerns about understanding technology and accessing relevant information compared to their urban counterparts. This suggests a need for more targeted training and information dissemination in rural settings.

Effect of Digital Competency Score (Beginner, Intermediate, Advanced)

The main effects of DCS were significant across all concern stages except for Informational concerns, meaning that digital competency plays a role in shaping teachers' attitudes toward technology adoption.Teachers with low digital competency (beginners) may struggle with basic technical skills and feel overwhelmed by technology adoption, leading to heightened concerns in the Personal and Management stages. These teachers may worry about their ability to effectively integrate technology into their lessons, the potential increase in workload, and the feasibility of managing technological tools in the classroom.

Those at an intermediate level may experience fewer self-efficacy concerns but still face challenges related to Collaboration and Consequences. They may recognise the value of technology but require additional support to enhance student learning outcomes and collaborate effectively with colleagues.

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Teachers with high digital competency (advanced) are likely to focus on higher-level concerns, such as Collaboration and Refocusing. Since they are more confident in their technology skills, their concerns shift toward maximising student benefits, improving teaching strategies, and sharing best practices with colleagues. The strongest main effect of DCS was observed in the Consequence stage ($F(2, 374) = 25.532$, $p < .001$, $\eta^2 = .120$), indicating that teachers' perceptions of how technology affects student learning are highly dependent on their digital competency levels.

Interaction Effects (SL × DCS)

The significant interaction effects between school location and digital competency for all concern stages highlight the complex relationship between these variables. The strongest interactions were observed in Consequence and Collaboration.

Consequence stage ($F(2, 374) = 13.806$, $p < .001$, $\eta^2 = .069$) suggests that teachers' beliefs about the impact of technology on student learning vary depending on both school location and digital competency. For example, rural teachers with beginner-level competency may doubt the effectiveness of technology due to resource limitations, whereas urban teachers with advanced competency may see greater benefits and focus on optimising outcomes.

Collaboration stage ($F(2, 374) = 11.696$, $p < .001$, $\eta^2 = .059$) indicates the level of peer support and professional collaboration related to instructional technology use is influenced by both geographical constraints and individual competency levels. In rural schools, teachers with lower digital competency may lack access to professional learning networks, while in urban schools, those with higher digital competency may be more actively engaged in collaborative efforts.

Discussion

The results of the univariate ANOVA reveal significant distinctions in teachers' SOC with respect to school location and DCS. The analysis indicates that urban teachers express heightened concerns at several SoC stages, specifically during the Informational, Personal, Collaboration and Consequence stages, illustrating the impact of context on their apprehensions regarding emerging technologies (Wang et al., 2019). There is a notable effect of DCS on five out of seven SoC stages, with teachers displaying high digital competency expressing increased concerns about technological effects on student learning outcomes. Furthermore, interaction effects between SL and DCS were identified, emphasising the differentiated responses from urban versus rural teachers concerning emerging technology adoption (Sillat et al., 2021). These findings underscore the necessity for localised strategies in professional development and policy-making to accommodate the diverse concerns stemming from varying digital competencies and geographic contexts.

Urban teachers exhibit heightened concerns in the Informational, Personal, and Consequence stages of emerging technology adoption, contrasted with their rural counterparts. At the Informational stage, urban teachers demonstrate apprehension regarding the specifics and conceptual understanding of these technologies, reflecting their need to comprehend new digital tools' potential and usage comprehensively (Spiteri & Chang Rundgren, 2020). As identified, the Personal stage involves concerns about the impact on their professional identity and roles, suggesting greater anxiety about integrating technology effectively within their existing pedagogical frameworks (Al-Furaih & Al-Awidi, 2020). Notably, the Consequence

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stage sees urban teachers particularly worried about the ramifications of technology on student learning outcomes, especially in advanced urban educational settings where expectations for technological efficacy are amplified compared to rural environments (Wang et al., 2019). These findings emphasise the need for targeted professional development initiatives that address the unique needs and challenges faced by teachers in urban settings, focusing on enhancing understanding and integration of emerging technologies (Portillo et al., 2020).

Teachers demonstrating elevated digital competency levels tend to manifest heightened anxiety about the ramifications on student learning outcomes, specifically at the Consequence stage (Portillo et al., 2020). This particular stage underscores concerns about how effectively emerging technologies can enhance or hinder educational objectives, particularly in relation to student performance and instructional outcomes (Falloon, 2020). Consequently, the presence of high digital competency correlates with a critical view of emerging technology adoption, influenced by an awareness of potential instructional challenges and opportunities (Al-Furaih & Al-Awidi, 2020). Thus, these findings highlight the essential role of digital competency in shaping educators' perspectives, prompting the necessity for further professional development programs that elevate digital skills, help alleviate anxiety, and ensure effective technology integration.

The results indicated key implications for professional development tailored by geographic and digital context, pivotal for effectively addressing teachers' concerns about emerging technologies. Specifically, the elevated concerns observed in urban areas suggest a need for enhanced programs that build on existing competencies while addressing urban-specific educational challenges (Portillo et al., 2020). In contrast, rural teachers, often with lower digital exposure, require strategies that both increase access to digital tools and improve basic digital skills, highlighting the significance of tailored interventions that consider structural limitations in these regions (Wang et al., 2019). Consequently, addressing structural challenges in rural education, such as limited access to resources, is essential to fostering an environment conducive to adaptive learning and technological acceptance (Hennessy et al., 2022). The diverse needs underscore the importance of crafting context-specific professional development programs that bridge the digital divide, thereby ensuring equitable technology integration across varying educational settings.

The interaction effects of SL and DCS show significant differences in the issues that the teachers seem to be concerned about when using technology. Teachers from urban context with higher DCS seem to be more worried about the details and effects that the use of new technologies will have on their teaching. Teachers from rural context appear to be less concerned about this, perhaps due to their lower access to the digital tools, which leaves less room for the development of high DCS in hopefully, this lowers their anxiety overall (Wang et al., 2019). As the exposure to the digital world differs, the urban teacher seems to be more concerned with how the technology relates to the immediate learning of their students, while the concern of the rural teachers is more with access to technology, which indicates that they need different kinds of professional development (Al-Furaih & Al-Awidi, 2020). It is relevant to provide a differentiated approach in this matter that caters for the contextual differences as highlighted in the findings, pointing out to the need of specific treatment that will fit the pedagogical demands and the difficulties concerning the logistics in the different settings.

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Tailoring professional development to enhance digital competency and address location-specific needs is crucial, given the nuanced differences highlighted in the findings. Urban teachers, who express greater concern about emerging technologies, require programs that build on existing digital skills while addressing the unique educational challenges of densely populated settings. Conversely, rural teachers, often with lower digital exposure, benefit more from foundational digital training that increases access and basic competencies (Hennessy et al., 2022). According to Fernández-Batanero, tailored interventions must account for the disparate conditions between urban and rural contexts to effectively support educators' transition into more digitalised teaching environments (Fernández-Batanero et al., 2022). Consequently, such contextually informed professional development can significantly contribute to bridging the digital divide, fostering equitable educational opportunities, and ensuring that teachers in varied locales can effectively integrate technology into their pedagogy.

Conclusion

The findings from this study highlight the persistent digital divide between urban and rural teachers in Sarawak, with significant differences in their SoC regarding emerging technologies adoption. Urban teachers, particularly those with higher DCS, exhibit greater concerns at later stages, particularly about the consequences of emerging technologies on student learning. In contrast, rural teachers, especially those with lower digital competency, tend to remain in the early concern stages, demonstrating lower engagement with digital tools due to infrastructural and socio-economic constraints.

Furthermore, these findings align with Malaysia’s broader Industrial Revolution 4.0 (IR 4.0) policy agenda, which emphasises the integration of advanced digital technologies in education to prepare future-ready citizens. Understanding how school location and digital competency influence teachers’ concerns about adopting emerging technologies provides critical insights for targeted interventions. In addition, addressing disparities between urban and rural schools, and tailoring professional development based on teachers’ digital readiness, are essential steps to achieving equitable and sustainable technology integration in line with the goals outlined in the Malaysia Education Blueprint and the National IR 4.0 Policy.

These disparities underscore the need for context-specific professional development programs that cater to the distinct needs of urban and rural educators. While rural teachers require foundational digital training and exposure, urban teachers benefit from advanced pedagogical strategies for emerging technologies integration. Additionally, policy interventions should prioritise infrastructure expansion, digital literacy programs, and targeted mentoring initiatives to bridge the digital gap effectively.

Future research should explore longitudinal interventions to track the progress of teachers across different concern stages and investigate how localised digital education policies can better support emerging technologies adoption in both urban and rural contexts. By addressing these challenges holistically, Sarawak can foster a more inclusive and equitable digital learning environment, ensuring that all educators, regardless of location, can effectively integrate emerging technologies into their teaching practices.

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