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# Bridging the Digital Divide: A Conceptual Framework on Teachers' Digital Competency and Students' Self-concept in a Rural Region

Sharifah Sara Hasliza Syed Hamid<sup>1\*</sup>, Rosilawati Sueb<sup>2</sup>

<sup>1,2</sup> Faculty of Education, Universiti Teknologi MARA Cawangan Selangor, Kampus Puncak Alam, 42300, Selangor, Malaysia

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## ABSTRACT

This article presents a conceptual framework based on technological pedagogical content knowledge (TPACK), Bandura's 1977 self-efficacy theory, and Bronfenbrenner's 1994 ecological systems theory as a lens through which teachers' digital competency relates to students' self-concept within a rural region. The model suggested that teachers with higher TPACK may develop effective, student-centred digital instruction that can enhance student engagement and digital self-efficacy, and lead to a positive digital self-concept. This result and the influence of context factors including school leadership, parent involvement, and national information communication, and technology policy highlight the influence of digital learning. The framework provided an overall perspective for mitigating the digital divide in underserved communities. Furthermore, empirical studies are needed to examine the relationships between the construct items of interest and guide equitable digital education interventions.

## 1. INTRODUCTION

Rural educators experience multiple obstacles to accessing digital competence training that responds to their localised contexts to enable embedding technology in teaching and learning. Most rural teachers are not exposed to higher-level pedagogical practices that involve using digital devices and seldom receive ongoing, localised professional development. This condition discourages rural teachers from using technology in teaching (Soekamto et al., 2022). Furthermore, inadequate training, poor infrastructure, and a lack of support systems have intensified the disparate digital literacy levels among urban and rural teachers (Wang & Zhang, 2024). The absence of professional development opportunities that cater to these locally specific challenges has resulted in rural teachers being less likely to adopt instructional practices that are most effective in supporting digital learning, which exacerbates educational inequalities

<sup>1\*</sup> Corresponding author. Sharifah Sara Hasliza Syed Hamid. *E-mail address:* dr.sarahasliza@gmail.com

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(Fernández-Arias et al., 2025). Hence, using accessible, context-specific digital literacy interventions is essential to enable rural teachers' facilitation of their students' learning opportunities.

Rural learning settings encounter persistent challenges that hinder equitable access to digital learning. These challenges include limited internet access, restricted digital technology device access, and inadequate technology support. These obstacles increase the digital divide and contribute to rural students' socioeconomic challenges and geographic isolation. For example, rural students in Sabah, Malaysia, struggled to access digital learning during the COVID-19 pandemic given their minimal or absent access to internet connectivity. Furthermore, some students were compelled to work part-time to buy digital devices and afford extra internet passes for online classes (Surianshah, 2021). The study revealed that, although the students' socioeconomic background did not directly affect their attendance, the availability of home digital access and a stable internet connection positively influenced their engagement. Moreover, the study highlighted the urgent need for enhanced internet access and digital devices in rural regions to bridge the digital divide and support equitable learning.

In China, despite the government's efforts, rural-urban educational inequalities persist with rural areas continuing to fall behind in educational investment, resources, and outcomes in rural regions (Xiang & Stillwell, 2023). Their findings suggest that education reform efforts have not sufficiently resolved these issues, which highlight the continued existence of deeply rooted educational disparities, despite considerable government efforts. The COVID-19 pandemic accelerated the incorporation of digital technology from an optional addition to a necessary resource for teaching and learning (Na et al., 2024). This highlights the importance of digital literacy for students and educators, particularly in areas like art education where digital tools can increase both efficacy in teaching methods and creative expression. However, the digital infrastructure for marginalised indigenous communities is inadequate, which further constrains digital learning and engagement (Fang et al., 2022). These systematic challenges should be addressed to overcome educational inequality, and more broadly, the digital divide in rural regions.

As rural schools frequently encounter challenges in following current teaching methods compared to urban schools, rural community socio-culture was a crucial factor in influencing how students used digital tools in their learning. Including local knowledge in rural education is considered vital for developing culturally relevant pedagogies that enhance students' engagement in learning and developing critical thinking and problem-solving, which are crucial 21<sup>st</sup> century skills (Fitrianto & Farisi, 2025). Additionally, parental attitudes and cultural values mediate students' information and communication technology (ICT) use, specifically where parental involvement and student academic achievement were strongly and positively related (Nurnisaa & Lestari, 2025). The aforementioned study indicated that parents' involvement in addressing challenges (unstable internet access and a lack of digital devices) by providing guidance and observation. Furthermore, the researchers emphasised that parental support was an additional microsystem variable when it interacts with teachers' technology use in schools and school resources to facilitate technology use in rural schools.

Policy implementation challenges prevail, and include budget inconsistency, logistical issues, poor planning efforts, and a "one-size-fits-all" plans that frequently obstruct technology implementation in rural regions (Donald & Hashim, 2025). Hence, a digital gap in terms of coverage and access to ICT persists between rural and urban areas despite national policies, such as the National Strategic Framework for Bridging the Digital Divide (NSF-BDD). Despite the considerable potential benefits of integrating ICT in rural education to improve educational access, the main barriers thereof are socio-economic constraints, a lack of trained personnel, and inadequate infrastructure. The total usage and effect of telecentres have decreased due to poor infrastructure, lack of training, and minimal participation from the local population (Donald & Hashim, 2025). These observations confirmed how reliance on a broader community-oriented framework beyond mere access can promote sustainable digital inclusion and literacy in rural Malaysia.

This article aimed to resolve the aforementioned cause-and-effect issues by developing a framework to provide an overview of rural teachers' digital competence and students' self-concept. The framework

combined a pedagogical framework (technological pedagogical content knowledge), theoretical psychology (Bandura's self-efficacy theory), and contextual feed-in (Bronfenbrenner's ecological system theory). The framework should provide an overall view of how digital learning activities generally affect students and how these can be enhanced. The results should guide future policies and research on equitable digital teaching practice.

## 2. THEORETICAL FRAMEWORK

### 2.1 *Technological Pedagogical Content Knowledge*

The TPACK is an instructional design model that focuses on incorporating technology with pedagogy and content knowledge. Teachers who integrate these three digital competency domains are more likely to create more authentic student-centred learning activities (Bwalya et al., 2023). The TPACK model is a theoretical underpinning that enables teachers to overcome context-based challenges, such as a lack of resources and poor digital tools, by adapting pedagogical strategies that are suitable to available resources while adhering to the pedagogy and curriculum to promote students' engagement and learning outcomes (Bwalya et al., 2023). This approach is consistent with the theoretical framework of this study. The framework emphasises the relationship between teachers' digital competency with training, facilities, and students' self-concept in promoting learning in underserved rural regions. Furthermore, the framework was supported by Aumann et al. (2023), where the model underscores the need to align teachers' digital competence with pedagogical practices and contextual factors to provide equal opportunities for technology-enhanced education. Thus, this model would benefit rural educators with limited resources and different student needs, and would be essential in establishing adaptive classroom teaching strategies.

The importance of TPACK is highlighted by Fanaturiza and Rindaningsih (2024), who argue that teacher must not only have digital literacies but also competent in utilising technology effectively in their teaching. Digitally competent teachers who also use TPACK incorporate interactivity and stimulus into their lessons that comply with curriculum requirements and also offer rich and personalised learning experiences. This approach is necessary to prepare students to an immersion in a technological landscape, being adequate to Industry 4.0 demands. The TPACK-based professional development increases teacher self-efficacy and fosters dynamic classroom environments (Joshi, 2023). These progressions are encouraged through developmental models, such as learning by design, lesson study, and microteaching. These models promote the development of integrated knowledge and classroom interactivity through collaborative practice and reflection (Wang & Zhang, 2024). Nevertheless, TPACK serves primarily as a framework aimed at improving educators integration of technology, pedagogy, and content knowledge, rather than as a direct solution for lesson planning (Singh & Malik, 2024).

The studies of Shoraevna et al. (2021) and Aumann et al. (2023) find several effective pedagogical strategies in digital environments for the rural contexts. The use of student-generated explainer videos (SGEV) that encourage active learning such as assigning students to create movies of animations explaining complex scientific concepts (Aumann et al., 2023). This approach integrates technology, pedagogy, and content knowledge (TPACK) and ultimately supports cognitive engagement, interactive learning, and cooperative group problem-solving, which is critical in resource-limited rural contexts. This highlights that context-based professional development, specifically in rural and diverse settings, is required to enable teachers for successful TPACK implementation and transform their teaching practice. Meanwhile, in the context of ICT tools such as interactive board and electronic tools, were found to complement teaching and learning, making blended learning particularly effective in rural regions (Shoraevna et al., 2021). These tools support flexible and interactive learning, thus increasing students' engagement and learning outcomes.

### 2.2 *Bandura's Self-Efficacy Theory*

Bandura's self-efficacy theory focuses on the importance of one's belief in their ability to accomplish a task. Teachers' confidence in using technology strongly impacts their readiness to embrace ICT-based teaching methods. This supports the notion that digital self-efficacy is imperative for effective technology

integration in education (Dwiastuti et al., 2025). Teachers develop this confidence through mastery, experience, and modelling, particularly in rural or under-resourced areas. A supportive school climate and discipline-specific, experiential teacher education are key to increasing digital self-efficacy. Furthermore, such conditions prepare teachers to act as models for technology use and explore digital use and students' self-perception. Psychological factors affected the adoption of mobile learning, as in a study conducted by Chen et al. (2024), which includes performance expectancy, effort expectancy, and social influence.

Empirical studies have demonstrated the relevance of digital self-efficacy as a factor in the successful implementation of technology-rich curricula. A study conducted among Grade 6 teachers by Escabarte and Gallardo (2024) found that teacher confidence and proficiency were strengthened by continuous professional development, peer collaboration, and positive peer feedback. Nevertheless, obstacles such as teaching large classes, and systematic barriers erode self-efficacy among students. Lawrent (2024) suggested that the satisfaction of mastery, social affirmation, and emotional well-being mediate a teacher's self-belief. Without this support, particularly in low- to middle-income settings, negative factors (stress and lack of support systems) can undermine confidence, which draws attention again to the importance of multifaceted approaches that address personal and contextual factors. Teachers with high confidence and robust digital self-efficacy are more inclined to use student-centred, higher-order pedagogical practices utilising technology, hence transforming traditional methods into interactive and collaborative learning settings (Abedi, 2024). Nonetheless, inflexible curricula and pressures of accountability can hamper these aspects.

Teachers with higher self-efficacy, supported by professional development and collaboration, exhibit greater confidence in incorporating technology into their teaching methodologies, resulting in effective distant learning (Berdousis, 2024). Furthermore, teachers' confidence influences their technological decision-making, as they are more inclined to adopt and proficiently incorporate digital tools into their teaching methodologies (Mayantao & Tantiado, 2024). Social support, aligned pedagogical beliefs, and relevant professional development foster stronger digital self-efficacy, specifically in rural or low-exposure contexts, which aid in bridging the digital divide and building students' digital competencies.

### *2.3 Bronfenbrenner's Ecological System Theory*

Wigati et al. (2025) posited that digital learning tools improve students' motivation and engagement, whilst variables (family income, educational levels, and home-school-community influence on students' usage of these resources) are important. Furthermore, the aforementioned study highlights that students' engagement with social media, such as Facebook, is a form of psychological digital engagement as it positively affects students with rural and low-socio-economic status backgrounds. Hence, this psychological dimension reinforces exo- and macrosystem factors, such as educational access and national policy, that facilitate student engagement and academic achievement. Bronfenbrenner's ecological system theory enables the assessment of students' digital engagement from multiple levels, from the immediate classroom to broader society influence.

This ecological approach can be applied to teachers' digital competencies as Dwiastuti et al. (2025) highlighted that teacher beliefs and self-efficacy (microsystem) are influenced by school leadership and peer networks (mesosystem), polemical district policy work and funding (exosystem), and national ICT strategies (macrosystem). The ICT is integrated in teaching by providing a supportive ICT infrastructure, and promoting educative collaboration among teachers to align the pedagogical and digital dimensions of teaching and learning. Feedback is another important psychological aspects in augmenting student motivation, self-efficacy, and engagement, stressing the importance of timely, personalised, and varied feedback types in online learning environments (Wang, 2025).

Drajati et al. (2023) explores the effect of a TPACK-based Teacher Professional Development (TPD) programme on EFL teachers' confidence and attitude on technology integration, the study highlights that personal, vicarious, and socio-cultural experience plays an important role in this context. Specifically, new

teachers develop confidence and competence based on a scaffolding of support. The incorporation of digital competence into the TPACK framework facilitates the dynamic interplay among technology, pedagogy, and subject knowledge within specific learning environments (Bwalya et al., 2023). The TPACK should be context-dependent, which is influenced by school culture and policy across various levels. Continuing growth at every ecological level is necessary to support the continued development of teacher digital competencies in alignment with technological and pedagogical advances and improving student learning outcomes.

### 3. CONCEPTUAL FRAMEWORK

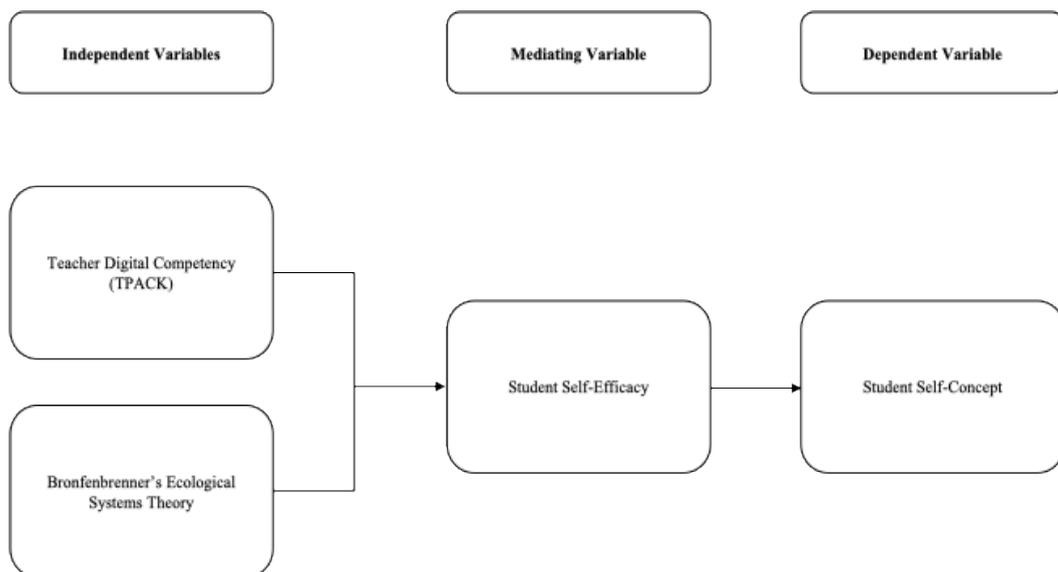
The theoretical model was centred on teachers' digital competence and is reflected through the TPACK model, which was developed to improve in-service teachers' technology use. This framework facilitates teachers to adapt teaching methods and integrate technology tools which are necessary for the need of digitally connected classroom. Teachers with digital competencies and familiar with TPACK are able to design interactive lessons that increase students' engagement while adhering to the curriculum. Moreover, teachers with strong TPACK are more prepared to create interactive, student-centred lesson plans that promote critical thinking even if they work in rural schools, which are typically under-resourced areas with limited digital resource access (Fanaturiza & Rindaningsih, 2024; Singh & Malik, 2024). Similarly, Wang and Zhang (2024) reported that TPACK application enriched the higher-order learning process by developing critical thinking, problem-solving, and collaborative learning among students. The integration of technology with pedagogy and content knowledge helps shape dynamic and engaging learning spaces, particularly in rural areas where digital tools enhance digital literacy and problem-solving capability. Thus, TPACK was an antecedent variable that supports purposeful student engagement and cognitive growth.

Students' self-efficacy based on the Bandura (1997) model was included as an independent variable for teachers' internalisation of learning confidence. Teachers who demonstrate digital fluency and provide structured, supported digital instruction increase students' confidence in their digital skills (Zghoul & Bataineh, 2024). This mechanism is enhanced by vicarious learning, where self-assured and well-trained teachers instilled confidence in their students in using technology. This is facilitated by observational learning where students would observe their teachers digital skilled and adopt these skills and eventually building their own self-efficacy. Additionally, Mayangsari et al. (2025) emphasise that intrinsic motivation, supported by professional development, is essential in influencing teachers' attitudes and creativity, hence improving student engagement and learning results. This intrinsic motivation increases their immersion with students and more importantly, motivated teachers are more likely to embrace new teaching methods, learn new techniques, and become more creative and adaptable.

Bronfenbrenner's ecological systems theory frames these teacher–student interactions in context and highlights nested systems from classroom contexts to broader policy gaps that can deeply influence digital tool usage and perceptions (Renn & Smith, 2023). This influence also includes a broader factor including policy gaps, access to resources, and society attitudes. This framework analyses the impact of digital tools adoption, while stressing on the importance of policy-level intervention with teacher training and schools' infrastructure, to enhance digital learning opportunities. Furthermore, Stanley and Kuo (2022) and Tong and An (2024) highlighted collaborative, systems-level efforts for teacher self-efficacy and student learning, specifically in rural settings. The aforementioned studies revealed that providing comprehensive assistance for rural students requires collaboration among stakeholders, learning institutions, teachers, parents, and communities. This collaborative approach is consistent with the need for tailored professional development programmes and community-level solutions to address digital education barriers in rural regions. Moderating factors are integral components of these interconnected ecological systems that demonstrate that a higher level of teachers' digital competency would improve students' performance.

The dependent variable in this study framework was the students' digital competence, which assessed the students' self-concept (how students felt about their digital skills in learning). These perceptions stem from teachers' digital skills with self-efficacy as the mediator and contextual ecological variables as

mitigators. Chiu et al. (2024) noted that teachers who were aware of technology in a resource-limited setting significantly affected their students' motivational and learning behaviour. Technology-aware teachers in an environment with few resource options could encourage students' motivation and ability to accomplish new learning tasks with confidence. The aforementioned study reported that teachers' digital skills in low-resource settings motivated student autonomy in study and performance task accomplishment. Digital technologies can be used to create more interactive learning environments that allow students to actively engage in problem-solving, research, and collaborative activities, which are crucial project-based learning (PBL) components. Additionally, integrating digital technology in PBL enhanced student engagement and academic results, thus fostering mastering and modelling in educational settings (Al-Abdullatif & Gameil, 2021). Developing digital technology in PBL is important to enable students to engage in active learning, performing tasks that are authentic, and use various digital resources. Furthermore, Zangani et al. (2020) reported that task relevance and quality feedback were important in constructing students' strong digital identity. The researchers determined that teachers who provided helpful advice and modelled digital participation aided students in forming good attitudes regarding their digital skills.



**Fig. 1.** Conceptual Framework of Teachers' Digital Competency and Students' Self-concept in Rural Sabah

This model emphasises the effect of teachers' digital competence and students' self-efficacy on students' self-concept, with ecological environment as a mediator. It underscores the role of the broader context and not simply instruction in shaping digital learning outcomes in rural areas, which provides important lessons for targeted interventions and equitable policy processes.

#### 4. DISCUSSION

The framework highlighted the relationship between teachers' digital competence and students' academic achievement in rural schooling settings with limited access to technology. Singh and Malik (2024) stated that TPACK is largely a conceptual framework aimed at enhancing teachers' integration of technology, pedagogy, and content knowledge, rather than a direct solution for lesson planning. Teachers with high TPACK were more likely to facilitate engaging and pedagogically coherent lessons that encouraged active learning and critical thinking (Bwalya et al., 2023; Fanaturiza & Rindaningsih, 2024). This framework provides teachers with methods to integrate digital tools with thorough pedagogy while promoting an environment in which students actively interact with the content. This approach is particularly important in

technology-enhanced classrooms, where students engage in collaborative and higher-order thinking following the meaningful integrated uses of technology. The TPACK provides a broader context for student learning through technology in a dynamic classroom. Hence, the model facilitates teachers' understanding of the relationship among the three domains and how technology can be used to support their teaching and convey information. Thus, TPACK enhances student engagement and learning outcomes.

In addition to teacher effectiveness, the model also emphasised the mediating functions of student self-efficacy and ecological systems on the learning outcome. Teachers' self-efficacy and ecological system have a significant impact on students' outcomes. Digitally competent teachers possess the ability to model adoptive behaviours and able to influence their students to adopt these skills in their digital learning (Escabarte & Gallardo, 2024; Zghoul & Bataineh, 2024). Teacher confidence and competence contribute to a supportive learning environment, evidenced by TPACK, as these teachers encourage students to think critically, and solve problems as well as engage in the active use of technology. Students who witness more effective technology use are more likely to develop positive beliefs about their own digital capabilities, hence increasing motivation and task engagement. As highlighted by (Chen et al., 2024), this corresponds with the necessity of enhancing teachers' digital skills by not only providing tools but also empowering educators with the knowledge and confidence to utilise them effectively. Nevertheless, this progress does not occur in isolation. Bronfenbrenner's ecological systems theory suggests that the larger ecology of learning, which includes family support, school culture, and societal norms, mitigates the effects of classroom teaching. These related systems can support or subvert digital capability development.

Having sustained training and continuing assistance are crucial for enabling teachers to incorporate new technologies into their methodologies (Chen et al., 2024). This approach is necessary to increase teachers' digital skills, leading to successful technology use in the classroom. Lifelong learning will help teachers develop confidence in integrating technology in the rural context, and learn to effectively use digital resources to enhance their students' learning. This corresponds with the necessity for customised digital literacy modules in teacher education to adequately prepare teachers for the demands of modern technology-integrated classrooms (Na et al., 2024). The incorporation of these modules into teacher education provides preservice teachers with tools for responding to the digital needs of contemporary classrooms which facilitate teachers in terms of preparation on how to effectively integrate technology in rural contexts. However, based on Aziz et al. (2024) study, instructor factors, including digital proficiency and engagement, were less impactful than student and content factors, underscoring the necessity for educators to emphasise content quality and student-centred methodologies. The study suggests that students and content factors have more impact on learning outcomes and this underscores the importance of effective distribution and engagement methods that support student motivation and learning.

Efforts to achieve meaningful digital learning in rural communities must target instructional practices and the broader ecologies in which they are situated. Systemic variables including parental engagement, administrative support, local infrastructure, and national ICT policy, affect teachers' readiness and the level of their students' interpretations (Renn & Smith, 2023). Thus, sustainable development in digital education requires interdisciplinary cooperation beyond the classroom. Digital equity and students' self-concept are fundamentally related issues in rural education that can only be addressed by the combined efforts of educators, family members, institutions, and policymakers.

## 5. SUGGESTIONS

The relationships identified in this conceptual framework should be tested through mixed-method or longitudinal designs in rural educational settings. Furthermore, how teachers' TPACK and students' self-efficacy interact at varying levels to influence students' self-concept considering the moderating effect of school leadership, parental involvement, and community structure should be examined. Furthermore, research of the long-term effects of culturally responsive digital training programmes on teacher practices and student outcomes would also contribute to knowledge on the sustainability of capacity-building. Moreover, comparisons between rural and urban schools may also reveal structural inequalities that would

aid in maximising inclusion and context-specificity when developing digital education policies and interventions.

## 6. CONCLUSION

This study presented a conceptual framework that linked teachers' digital competence (TPACK) and students' self-efficacy (Bronfenbrenner's ecological system theory) to elucidate the construction of student self-concept in rural schools. This model was intended to guide digital divide intervention programmes and the empowerment of digitally competent learners in under-resourced communities. The framework demonstrated that effective digital learning does not merely refer to technological access, but also the role of confident, digitally competent teachers and broader sociocultural system support. Understanding these inter-related drivers and how they work together to shape student outcomes would enable the development of inclusive, context-specific actions by educators, researchers, and policymakers that mitigate systemic obstacles.

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## CONFLICT OF INTEREST STATEMENT

The authors confirmed there is no conflict of interest in this article.

## AUTHORS' CONTRIBUTIONS

Sharifah Sara Hasliza Syed Hamid wrote and draft the paper, developed the conceptual framework and integrated the theoretical models employed. Rosilawati binti Sueb contributed by reviewing and editing the manuscript and making suggestions. Both authors worked jointly on this paper and approved final version for submission.

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### About the Authors

*Sharifah Sara Hasliza Syed Hamid*, is a PhD student in the Department of Education at Universiti Teknologi MARA (UiTM) Puncak Alam. Her main research activity focuses on digital competency and self-concept in education. Her doctoral work explores the relationship between teachers' digital skills and students' academic self-perception in technology-enhanced learning environments. She can be reached via email at [dr.sarahasliza@gmail.com](mailto:dr.sarahasliza@gmail.com)

*Rosilawati binti Sueb*, (Dr.) is a Senior Lecturer in the Department of Educational Studies, Faculty of Education at Universiti Teknologi MARA (UiTM). Her areas of expertise include Educational Psychology and Classroom Management. She has contributed to various research projects and publications that focus on learner development, instructional strategies, and effective classroom practices. She can be reached via email at [rosil334@uitm.edu.my](mailto:rosil334@uitm.edu.my)