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SCAFFOLDING SELF-REGULATED LEARNING THROUGH TEACHERS' TPACK: A CONCEPTUAL MODEL

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ABSTRACT
The present article presents a discourse of a conceptual model that bridges the gap between Technological Pedagogical Content Knowledge (TPACK) and Self-Regulated Learning (SRL). The study synthesizes existing literature to explore how teachers' TPACK aligns with the phases of SRL, which include forethought, performance, and self-reflection. The research identifies critical issues in current educational practices, highlighting that even teachers with advanced TPACK often struggle to design lessons that effectively scaffold SRL. Empirical evidence indicates that many educators lack structured strategies to guide students in developing essential self-regulation skills, such as goal-setting and progress monitoring, and often prioritize technical proficiency over pedagogical strategies that support SRL.

To address these challenges, this article proposes a cohesive framework that connects TPACK with SRL, suggesting that technology can serve as a catalyst for enhancing self-regulation in learning environments. The model emphasizes the importance of teachers' technological knowledge in selecting and applying digital tools that foster SRL, such as digital self-assessment tools and adaptive learning platforms. Furthermore, the article discusses future research directions, advocating for studies that investigate the interaction between TPACK and SRL in real-world classroom settings to validate the proposed framework and its practical implications. Overall, this conceptual model aims to provide educators with a structured approach to integrate technology effectively, thereby enhancing students' self-regulated learning experiences.

KEYWORDS: *Technological Pedagogical Content Knowledge (TPACK), Self-Regulated Learning (SRL), Learning Strategies, Goal-Setting, Self-Reflection, Scaffolding.*

1.0 INTRODUCTION

The rapid advancement of technology and digital tools in 21st-century education has changed pedagogical practices. Now modern educators are increasingly required to develop Technological, Pedagogical and Content Knowledge (TPACK). It is a framework that presents the interplay between teachers' ability to combine deep subject knowledge (Content Knowledge, CK), pedagogical skills (Pedagogical Knowledge, PK) and technological proficiency (Technological Knowledge, TK) to create meaningful learning experiences and effective instruction (J. H. L. Koh, 2019; Sui et al., 2024). In parallel, Self-Regulated Learning (SRL) has emerged as a strong determinant of academic success and a cornerstone of 21st-century education. It empowers the students to plan, monitor and evaluate/reflect on their own learning process (Huang et al., 2023; Sui et al., 2024). Being independent in learning ensures learning autonomy and a lifelong learning attitude in students (Zimmerman, 2002). However, there is a rapid shift towards a digital, hybrid and blended learning environment, where learners often learn with minimal direct supervision, especially in the post-pandemic era. In such a scenario, research shows that although metacognitive strategies such as self-reflection and self-monitoring play a crucial role in promoting SRL (Pintrich, 2004; Schraw et al., 2006), students often lack these basic skills, while teachers struggle to scaffold SRL effectively with digital tools.

For instance, Huang L. (2021) found that a teacher's capacity to self-regulate his/her own learning greatly affects his/her ability to design technology-rich lessons. It suggests a bidirectional relationship between TPACK and SRL (Huang, 2021). Similarly, recent studies have also shown that such teachers who possess robust SRL strategies are more successful in integrating self-regulation in students. This becomes crucial in the current technology-rich environment to ensure technology enhances—rather than disrupts—autonomous learning (Huang et al., 2023; Sui et al., 2024). This synergy keeps TPACK not only as a technical proficiency but also as a scaffold for cultivating SRL. This cultivation is very important in science and STEM education because of the specialized needs of these fields for adaptive platforms, simulations, and virtual labs. (Niess & Niess, 1 C.E.; Sui et al., 2024)

1.1 Research Problem

Despite well-documented recognition of both TPACK and SRL as critical competencies, there exists a significant theoretical and practical gap in understanding **how teachers can leverage their TPACK competency to systematically scaffold students' SRL.** Various empirical evidence shows that teachers often lack structured strategies to guide students in developing robust self-regulation skills such as goal-setting, progress monitoring and self-reflection (Huang, 2021; J. H. L. Koh, 2019). Also, they lack the strategies to integrate digital tools effectively with SRL phases (forethought, performance and self-reflection) (Azevedo & Cromley, 2004). For example, a study done by Sui (2024) on 192 Taiwanese teachers reveals that although SRL positively influenced TPK and TCK, these intersections were rarely operationalized in classroom practices (Sui et al., 2024).

Furthermore, various in-service and pre-service teachers' professional development programmes often prioritize technical proficiency over pedagogical strategies to support SRL. This leads to fragmented, superficial technology integration. Niess (2018) has also underscored this issue that even the teachers with higher or advanced TPACK often fail to design lessons that explicitly scaffold SRL (Niess & Niess, 2018). Given these challenges and disconnects, there is an urgent need for a cohesive framework that connects TPACK with SRL. It will ultimately design a learning environment in which technology serves as a catalyst for self-regulation.

1.2 Objective of the paper

This paper addresses the aforementioned gap between TPACK and SRL by pursuing three key objectives and proposing future research directions:

1. To synthesize existing literature and research on TPACK and SRL in order to find out exactly how teachers' TPACK align with SRL phases (forethought, performance and self-reflection).
2. To propose a conceptual framework that draws upon empirical evidence from recent studies to provide actionable strategies for scaffolding SRL through TPACK.
3. To provide evidence-based recommendations for educators and policymakers, emphasizing the role of adaptive scaffolding, multimodal learning analytics and reflective teaching practices in TPACK-SRL integration.
4. To suggest areas for empirical investigation to further validate and refine the proposed conceptual model.

2.0 THEORETICAL FOUNDATION

2.1 Self-Regulated Learning (SRL)

2.1.1 Definitions and key components

SRL is a multidimensional construct which encompasses such cognitive, metacognitive, motivational and behavioural processes that enable learners to actively control their own learning trajectories through goal-setting, strategy-selection, self-monitoring and self-reflection (Zimmerman, 2002). Zimmerman (1986) gave three cyclical and interconnected phases of SRL:

i. **Forethought Phase:** In this initial phase, there are three basic steps – Goal-setting, strategic planning and establishing self-efficacy/motivational beliefs. (Pintrich, 2004) emphasizes that this phase sets the groundwork for effective learning.

ii. **Performance Phase:** During this phase, learner implement their planned strategies and constantly keeps monitoring their progress in real time. Here active use of various metacognitive prompts helps students to make adjustments as necessary (Schraw et al., 2006).

iii. **Self-Reflection Phase:** During this final phase, learners review and evaluate their performance. Causal attribution (the psychological process of identifying and assigning a reason or cause to an event or behaviour, retrospectively) and iterative adjustments (continuously reviewing and modifying your behaviours or strategies based on your self-assessment of your performance, making small adjustments over time until you achieve your desired outcome) are done.

Figure 1:Three-phase, cyclical model of self-regulated learning (SRL). (Andrews et al., 2023)

2.1.2 Importance of SRL in Digital, Hybrid and Blended Learning Environment

In technology-rich classrooms, SRL is critical for sustained engagement. The main issue with Blended and hybrid or digital learning environments is the lack of direct supervision. In this type of situation, learner must independently regulate their learning (Dabbagh et al., 2004). A 2004 study found that students who were in a hybrid academic environment with

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strong SRL skills had 23% better academic performance. The main reason researchers found was that such students leveraged adaptive platforms and real-time feedback systems (Zhao et al., 2024). (Huang et al., 2023) identified that such students whose teachers embedded SRL strategies in online lessons were more able to self-monitor their progress using the learning analytics dashboard. This also aligns with Zimmerman's assertion that SRL fosters resilience in a dynamic learning ecosystem.

2.2 TPACK

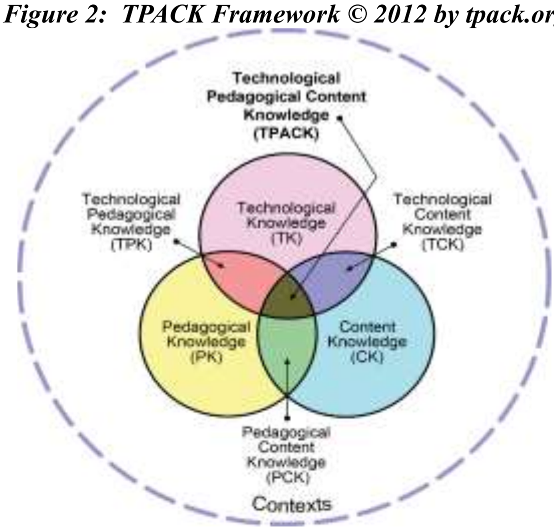
2.2.1 Overview of the TPACK framework

The TPACK framework, as developed by Mishra & Koehler (2006), building upon the foundational work of Shulman (1987) and Shulman (1986)It is based on the intersection of technological, pedagogical, and content knowledge—three core knowledge domains —and their integration, which ultimately ensures effective teaching in technology-enhanced environments.

As shown in Figure 2, the three core domains of TPACK are:

- **Content Knowledge (CK):** The subject-specific expertise a teacher possesses.
- **Pedagogical Knowledge (PK):** The understanding of the teacher about teaching methodologies, learning processes, and instructional strategies.
- **Technological Knowledge (TK):** Teacher's proficiency with digital tools and resources.

Figure 2: TPACK Framework © 2012 by tpack.org



The intersections of them—TPK, PCK and TCK—ultimately culminate in TPACK. It represents the synergistic application of technology for effective pedagogy (Ning et al., 2024).

2.2.2 Role of TPACK in Enhancing Instruction

J. Koh et al. (2013) have found in their study that teachers with advanced TPACK competencies were most likely to create SRL-supportive, interactive lessons using tools such as virtual labs. Similarly, Chai et al. (2013) found that TPACK-trained teachers were highly responsible for improved student outcomes, due to their integration of multimedia resources that scaffold critical thinking and problem-solving abilities. This was again backed by a study by Niess & Niess (2018). Additionally, researchers have suggested that TPACK is not static; in fact, it evolves and develops through continuous professional development through reflective practices. It makes it a dynamic asset in a techno-rich instructional environment (Harris et al., 2009).

2.3 The Interplay between TPACK and SRL

2.3.1 Empirical Evidence Linking TPACK and SRL

Recent studies have shown a bidirectional relationship between TPACK and SRL. For instance, (Kramarski & Michalsky, 2009) found that teachers who were better equipped to adapt TPACK (such as using adaptive quizzes to personalize instruction) necessarily had strong SRL skills. (Lee & Tsai, 2010) confirmed that TPACK-focused metacognitive training enhances pre-service teachers' SRL. This enables them to align technology with students' needs. A study by Valtonen et al. (2015) demonstrated that SRL mediates the relationship between TPACK and deep learning outcomes, with technology self-efficacy acting as a moderating factor.

2.3.2 Challenges in operationalizing TPACK for SRL scaffolding.

Despite the promising empirical connections and theoretical alignment, practical barriers persist:

- **Fragmented Professional Development:** (Niess & Niess, 2018) noted that most of the teacher training programs focus on technical skills rather than SRL integration. It ultimately leads to superficial implementation. And for the same reason, the teacher with advanced TPACK may struggle to design lesson plans that explicitly scaffold phases of SRL—namely, Goal-setting, progress monitoring and reflective evaluation(Azevedo & Cromley, 2004).
- **Contextual Misalignment:** A systematic review by Scherer et al. (2017) revealed that cultural and socioeconomic factors, such as unequal access to digital tools, are often overlooked in most of the available TPACK-SRL models.
- **Measurement Gap:** As Huang et al. (2023)MMLA (Multimodal learning analytics) offers promise; they also emphasized that most assessments rely only on self-reports, which fail to capture real-time SRL behaviour, especially during lesson planning.

Additionally, the fragmented nature of existing research has led to inconsistent application of digital tools in supporting self-regulation. This superficial integration fails to address the complexities of metacognitive scaffolding in varied learning environments.

3.0 THE PROPOSED CONCEPTUAL MODEL

3.1 Model overview and Rationale

Although TPACK provides a structured approach to integrating technology effectively in education (P. Mishra & Koehler, 2006), mere presence of technology and digital tools in the classroom does not automatically enhance the student's learning; rather, its impacts depend on the teacher's strategies to leverage digital tools to support the SRL process (Kramarski & Michalsky, 2009). This conceptual model proposes that teachers' TPACK competencies can serve as a structured scaffold for SRL. It can ensure that students become actively engaged, self-regulated learners rather than passive recipients of technology.

This model builds on Zimmerman's (2002) cyclical phases of SRL. It aligns the three phases of SRL with various TPACK competencies to create an adaptive, techno-enhanced learning environment. Also, this model provides actionable strategies for teachers by synthesizing prior research on TPACK and SRL (Lee & Tsai, 2010; Valtonen et al., 2015). By using these strategies, teachers can cultivate self-regulated learners while ensuring optimal use of their digital tools.

3.2 Role of TPACK components in scaffolding SRL

3.2.1 TK and SRL

Teachers' technological knowledge enables them to select and ensure optimal and proper application of digital tools to foster SRL. For instance, various studies show that platforms offering real-time analytics, real-time and adaptive feedback systems support metacognitive processes (Harris et al., 2009), enabling students to monitor their learning trajectories and adjust strategies dynamically (Huang et al., 2023; Sui et al., 2024). TK can scaffold SRL through Digital self-assessment tools (such as learning analytics dashboards) for tracking progress, AI-driven applications to automate formative assessment (G. Mishra, 2024; G. Mishra et al., 2024). Studies have also shown that TK-mediated environments, such as interactive simulations or gamified learning modules, promote goal setting and self-evaluation by making abstract concepts tangible (Otrel-Cass et al., 2012).

3.2.2 PK and SRL

Teachers' pedagogical knowledge enables them to design such instructional strategies that align with students' cognitive and metacognitive needs and explicitly teach SRL skills in the process. PK promotes teachers to use metacognitive prompts, a peer-assessment framework and inquiry-based activities in order to cultivate students' planning and reflection abilities (Thohir et al., 2025). For instance, the DECODE model integrates SRL micro-units with technology-enhanced workshops and shows that PK-driven scaffolding (such as co-reflective discussion and iterative goal refinement) enhances students' regulatory behaviours (Sui et al., 2024). Furthermore, PK allows teachers to use various other scaffolding techniques, such as think-aloud protocols and guided questioning (Dabbagh & Kitsantas, 2012)Formative feedback loops to ensure students monitor and adjust their learning strategies (Azevedo & Cromley, 2004), and collaborative learning structures to leverage peer-assisted SRL development (Schraw et al., 2006).

3.2.3 CK and SRL

Teachers' content knowledge ensures that SRL strategies align with disciplinary demands. For example, in science education, teachers use CK to select technical tools to enable students to test hypotheses and perform data analysis (which are some key SRL skills) (Otrel-Cass et al., 2012) . CK also ensures the creation of domain-specific scaffolds, such as concept maps for organizing complex information in social studies and rubrics for self-assessment in mathematics. (J. H. L. Koh, 2019; Zhao et al., 2024). The selection of discipline-specific scaffolds, such as reflective writing exercises in the humanities, promotes critical self-assessment and metacognitive awareness (Pintrich, 2004).

3.2.4 TPK and Adaptive learning environments

Technological and pedagogical knowledge bridges technology and pedagogy, which allows teachers to use adaptive learning ecosystems such as AI-powered platforms like ChatGPT, which can generalize personalized learning pathways(Kennedy & Ruifang Hope Sun, 2024; G. Mishra, 2024). TPK also facilitates the use of MMLA to combine log data and think-aloud to diagnose SRL gaps (such as time management, resource selection and allocation), which is crucial for delivering in-time interventions (Huang et al., 2023).

3.2.5 TCK and Discipline-specific SRL tools

Technological content knowledge enables teachers to identify technologies which can enhance content delivery while embedding SRL opportunities. For instance, in language teaching, tools such as speech recognition software provide immediate pronunciation feedback, which can ultimately foster self-correction and persistence (Thohir et al., 2025). Similarly, in STEM, TCK-driven tools such as coding simulators or data loggers enable students to iteratively test solutions, aligning with SRL phases such as performance control and reflection. TCK-informed video scaffolding—such as pausing to analyse experiments—supports students' metacognitive monitoring by visualizing cause-and-effect relationships (Otrel-Cass et al., 2012).

3.2.6 PCK and Metacognitive Dialogue

Pedagogical content knowledge enables teachers to identify or develop subject-specific teaching methods that can promote SRL. For instance, a history teacher might use debates to scaffold argumentation skills and prompt students to evaluate evidence and raise claims (which is a crucial SRL process in the evaluation phase) (J. H. L. Koh, 2019). PCK also supports the students in creating their reflective journals, where they explore thematic connections and articulate their learning challenges. These practices are grounded in Vygotskian principles, where teacher-student interaction helps externalize metacognitive processes, which further makes them visible and easier for students to regulate and refine (Azevedo & Hadwin, 2005).

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3.2.7 TPACK and Holistic SRL Ecosystem

The dynamic interplay among TPACK components can create a holistic environment that synergizes technology, pedagogy, and content to support SRL. For example, a teacher might design a flipped classroom (TPK) using various video resources (TCK) paired with self-assessment quizzes (PK) to foster preparatory goal-setting and post-lecture reflection. Studies have shown that, as integrated knowledge enables nuanced adjustments to instructional scaffoldings, TPACK mediates the relationship between teachers' competencies and students' SRL outcomes.

3.3 Phases of SRL and Corresponding TPACK Strategies

SRL Phase	Components	Sub-components	TPACK-Based Scaffolding Strategies	Example Tools/Methods
Forethought Phase	Task Analysis	**Goal Setting**	Teachers use **TK** (e.g., digital goal-setting platforms) to guide students in defining measurable learning objectives aligned with curriculum standards.	Learning management systems (e.g., Canvas), SMART goal apps (e.g., Trello).
		Strategic Planning	Teachers apply **PK** to design scaffolded lesson plans that break complex tasks into manageable steps, leveraging adaptive technologies.	Interactive timelines (e.g., Lucidchart), project management tools (e.g., Asana).
	Motivational Beliefs	**Self-Efficacy**	Teachers employ **CK** to contextualize tasks (e.g., virtual labs in STEM) that build confidence through mastery experiences.	Adaptive learning platforms (e.g., Khan Academy), gamified quizzes (e.g., Kahoot).
		Outcome Expectations	Teachers model **TPK** by demonstrating how digital tools (e.g., simulations) align with learning outcomes.	Virtual reality (VR) simulations (e.g., Labster), predictive analytics dashboards.
		Intrinsic Interest	Teachers use **TCK** to integrate subject-specific multimedia (e.g., interactive videos) that spark curiosity.	Augmented reality (AR) apps (e.g., Merge Cube), multimedia storytelling tools.
		Goal Orientation	Teachers design **PCK**-driven tasks that align with students' intrinsic and extrinsic motivations (e.g., competency-based learning).	Badging systems (e.g., Classcraft), competency trackers.
Performance Phase	Self- Control	**Self-Instruction**	Teachers model **TPK** through think-aloud videos that demonstrate problem-solving strategies in real time.	Video tutorials (e.g., Khan Academy), annotated coding workflows (e.g., Jupyter Notebook).
		Imagery	Teachers use **TK** to create visual aids (e.g., concept maps) that help students mentally simulate tasks.	Mind-mapping software (e.g., MindMeister), 3D modeling tools (e.g., Tinkercad).
		Attention Focusing	Teachers employ **PK** to design distraction-free digital environments (e.g., focus mode settings).	Browser extensions (e.g., StayFocusd), mindfulness apps (e.g., Headspace).
		Task Strategies	Teachers apply **CK** to curate discipline-specific tools (e.g., coding sandboxes for computer science).	Coding platforms (e.g., Scratch), subject-specific apps (e.g., GeoGebra).
	Self-Observation	**Self-Recording**	Teachers use **TK** to implement learning analytics dashboards that track progress in real time.	LMS analytics (e.g., Moodle), wearable devices (e.g., Fitbit for engagement metrics).
		Metacognitive Monitoring	Teachers integrate **TPACK** by combining formative assessments (PK) with adaptive feedback systems (TK).	AI-driven tutoring systems (e.g., Carnegie Learning), reflective journals (e.g., Padlet).
Self-Reflection Phase	Self-Judgement	**Self-Evaluation**	Teachers use **PK** to design rubrics that guide students in critiquing their work against predefined criteria.	Digital rubrics (e.g., Rubistar), peer review platforms (e.g., Peergrade).
		Causal Attribution	Teachers apply **CK** to contextualize feedback (e.g., linking outcomes to strategy use in science experiments).	E-portfolios (e.g., Seesaw), causal mapping tools (e.g., CMapTools).
	Self-Reaction	**Self-Satisfaction**	Teachers leverage **TK** to create digital badges or certificates that reward progress, fostering intrinsic motivation.	Badge systems (e.g., Credly), gamified achievement trackers.
		Adaptive Inferences	Teachers use **TPACK** to design iterative improvement plans (e.g., adaptive learning paths based on reflection data).	AI-driven recommendation engines (e.g., Knewton), adaptive learning platforms.

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4.0 GUIDELINES FOR EDUCATORS AND POLICYMAKERS

While this paper primarily focuses on the theoretical intersection of TPACK and SRL, it is critical to recognize the broader practical implications for educators and policymakers. The effective incorporation of TPACK into instruction can considerably improve students' self-regulated learning by offering structured opportunities for goal-setting, self-monitoring and self-reflection. Teachers who strategically integrate digital resources into their lesson plans can build adaptive learning environments that promote autonomy and metacognitive participation.

Professional development training programmes should highlight the alignment between TPACK and SRL techniques, equipping educators with the skills to effectively scaffold self-regulated learning. In addition, policymakers should encourage the incorporation of SRL-focused pedagogies into teacher education curricula and invest in digital infrastructure to enable equitable access to technology-enhanced learning environments.

5.0 FUTURE RESEARCH DIRECTIONS

Despite the theoretical advancements presented in this paper, further research is required to explore the interaction between TPACK and SRL in real-world classrooms. Key areas for future research include:

- Empirical validation of the proposed model in diverse educational settings (such as school teaching and in higher education settings)
- Cultural Adaptation for understanding how cultural and socioeconomic factors influence the implementation of TPACK-SRL integration.
- Longitudinal Studies are required to investigate the long-term effects of this type of scaffolding on student outcomes, such as motivation, academic outcomes and lifelong learning skills
- AI and learning analytics must be explored to know how AI-driven tools and MMLA can enhance the model's effectiveness in real-time SRL scaffolding.
- Comparative Analysis across different subject domains may provide valuable insights.
- Development of a professional development framework that enhances teachers' ability to implement SRL-Supportive Strategies effectively.

6.0 CONCLUDING REMARKS

In contemporary digital and blended learning environments, effective teaching requires more than technological proficiency; it demands the purposeful integration of technology, pedagogy, and content in ways that actively support students' self-regulated learning. This paper has attempted to conceptually bridge the TPACK framework and SRL by demonstrating how teachers' technological, pedagogical, and content-related competencies can collectively scaffold learners' goal-setting, strategic planning, self-monitoring, reflection, and adaptive learning behaviours.

The proposed conceptual model emphasizes that technology becomes educationally meaningful only when it is pedagogically structured to promote learner autonomy and metacognitive engagement. By aligning TPACK components with the cyclical phases of SRL, the framework provides a theoretically grounded and practically relevant perspective for designing technology-enhanced learning environments that foster active and independent learning.

Although the model remains conceptual in nature, it offers important implications for teacher education, instructional design, and professional development in the 21st-century educational landscape. Future empirical investigations across diverse educational settings may further validate and refine the proposed framework, thereby contributing to the development of more adaptive, reflective, and self-regulated learning ecosystems.

REFERENCES

1. *Andrews, M. A., Okuliar, C. A., Whelton, S. A., Windels, A. O., Kruse, S. R., Nachnani, M. G., Topol, D. A., McBee, E. C., Stein, M. T., Singaraju, R. C., Gao, S. W., Oliver, D. S., Mangal, J. P., Larochelle, J. S., Kelly, W. F., Dezee, K. J., Chen, H. C., Artino, A. R., Hemmer, P. A., … Durning, S. J. (2023). Using Self-Regulated Learning Microanalysis to Examine Regulatory Processes in Clerkship Students Engaged in Practice Questions. Perspectives on Medical Education, 12(1), 385–398. https://doi.org/10.5334/PME.833*
2. *Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? Journal of Educational Psychology, 96(3), 523–535. https://doi.org/10.1037/0022-0663.96.3.523*
3. *Azevedo, R., & Hadwin, A. F. (2005). Scaffolding self-regulated learning and metacognition - Implications for the design of computer-based scaffolds. Instructional Science, 33(5–6), 367–379. https://doi.org/10.1007/S11251-005-1272-9*
4. *Chai, C.-S. S., Koh, J. H.-L., & Tsai, C.-C. (2013). A Review of Technological Pedagogical Content Knowledge. In Educational Technology & Society (Vol. 16, Issue 2).*
5. *Dabbagh, N., Dabbagh, N., & Kitsantas, A. (2004). Supporting Self-Regulation in Student-Centered Web-Based Learning Environments. International Journal on E-Learning, 3(1), 40–47.*
6. *Dabbagh, N., & Kitsantas, A. (2012). Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. The Internet and Higher Education, 15(1), 3–8. https://doi.org/10.1016/J.IHEDUC.2011.06.002*
7. *Harris, J., Koehler, M., & Mishra, P. (2009). What Is Technological Pedagogical Content Knowledge? Contemporary Issues in Technology and Teacher Education, 9.*
8. *Huang, L. (2021). Developing technological pedagogical content knowledge in technology-rich learning environments: The affordances of self-regulated learning theory. McGill University.*

https://escholarship.mcgill.ca/concern/theses/6d570246j?locale=en

9. Huang, L., Doleck, T., Chen, B., Huang, X., Tan, C., Lajoie, S. P., & Wang, M. (2023). Multimodal learning analytics for assessing teachers' self-regulated learning in planning technology-integrated lessons in a computer-based environment. Education and Information Technologies, 28(12), 15823–15843. https://doi.org/10.1007/S10639-023-11804-7/METRICS
10. Kennedy, J., & Ruifang Hope Sun, S. E. S. C. (2024). Inviting AI as a Collaborator: New perspectives for TPACK. Society for Information Technology & Teacher Education International Conference. https://www.academia.edu/122271659/Inviting_AI_as_a_Collaborator_New_perspectives_for_TPACK
11. Koh, J., Chai, C., & Tsai, C.-C. (2013). Demographic Factors, TPACK Constructs, and Teachers' Perceptions of Constructivist-Oriented TPACK. Educational Technology and Society, 17, 185–196.
12. Koh, J. H. L. (2019). TPACK design scaffolds for supporting teacher pedagogical change. Educational Technology Research and Development, 67(3), 577–595. https://doi.org/10.1007/S11423-018-9627-5/METRICS
13. Kramarski, B., & Michalsky, T. (2009). Investigating Preservice Teachers' Professional Growth in Self-Regulated Learning Environments. Journal of Educational Psychology, 101(1), 161–175. https://doi.org/10.1037/A0013101
14. Lee, M. H., & Tsai, C. C. (2010). Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World wide Web. Instructional Science, 38(1), 1–21. https://doi.org/10.1007/S11251-008-9075-4/METRICS
15. Mishra, G. (2024). Futuristic Perspective of Emerging AI In Teaching-Learning And Evaluation. MGKVP.
16. Mishra, G., Nath Pandey, K., Tripathi, R., Kumar Singh, R., Scholar, Me., Gandhi Kashi Vidyapith, M., & Gamil, V. I. (2024). Using AI for student's evaluation: Opportunities and Challenges. Journal for ReAttach Therapy and Developmental Diversities, 7(6), 525–530. https://doi.org/10.53555/JRTDD.V7I6.3452
17. Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge PUNYA MISHRA. Teachers College Record, 108(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x
18. Niess, M. L., & Niess, M. L. (1 C.E.). Scaffolding Subject Matter Content With Pedagogy and Technologies in Problem-Based Learning With the Online TPACK Learning Trajectory. Https://Services.Igi-Global.Com/Resolvedoi/Resolve.Aspx?Doi=10.4018/978-1-5225-5631-2.Ch040, 2, 914–931. https://doi.org/10.4018/978-1-5225-5631-2.CH040
19. Niess, M. L., & Niess, M. L. (2018). Scaffolding Subject Matter Content With Pedagogy and Technologies in Problem-Based Learning With the Online TPACK Learning Trajectory. Https://Services.Igi-Global.Com/Resolvedoi/Resolve.Aspx?Doi=10.4018/978-1-5225-5631-2.Ch040. https://doi.org/10.4018/978-1-5225-5631-2.CH040
20. Ning, Y., Zhang, C., Xu, B., Zhou, Y., & Wijaya, T. T. (2024). Teachers' AI-TPACK: Exploring the Relationship between Knowledge Elements. Sustainability (Switzerland), 16(3), 978. https://doi.org/10.3390/SU16030978/S1
21. Otrel-Cass, K., Khoo, E., & Cowie, B. (2012). Scaffolding With and Through Videos: An example of ICT-TPACK. Contemporary Issues in Technology And Teacher Education, 12(4), 369–390. https://vbn.aau.dk/en/publications/scaffolding-with-and-through-videos-an-example-of-ict-tpack
22. Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. Educational Psychology Review, 16(4), 385–407. https://doi.org/10.1007/S10648-004-0006-X/METRICS
23. Scherer, R., Tondeur, J., & Siddiq, F. (2017). On the quest for validity: Testing the factor structure and measurement invariance of the technology-dimensions in the Technological, Pedagogical, and Content Knowledge (TPACK) model. Computers & Education, 112, 1–17. https://doi.org/10.1016/J.COMPEDU.2017.04.012
24. Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. Research in Science Education, 36(1–2), 111–139. https://doi.org/10.1007/S11165-005-3917-8/METRICS
25. Shulman, L. (1987). Knowledge and Teaching:Foundations of the New Reform. Harvard Educational Review, 57(1), 1–23. https://doi.org/10.17763/HAER.57.1.J463W79R56455411
26. SHULMAN, L. E. E. S. (1986). Those Who Understand: Knowledge Growth in Teaching. Educational Researcher, 15(2), 4–14. https://doi.org/10.3102/0013189X015002004
27. Sui, C. J., Yen, M. H., & Chang, C. Y. (2024). Teachers' perceptions of teaching science with technology-enhanced self-regulated learning strategies through the DECODE model. Education and Information Technologies, 29(17), 22813–22839. https://doi.org/10.1007/S10639-024-12715-X/TABLES/9
28. Thohir, M. A., Yanti, F. A., Handayani, R. D., & Halim, L. (2025). Relationship of TPACK, motivation, self-regulation, and learning performance on preservice primary school teachers. International Journal of Evaluation and Research in Education, 14(1), 188–197. https://doi.org/10.11591/IJERE.V14I1.30144
29. Valtonen, T., Kukkonen, J., Kontkanen, S., Sormunen, K., Dillon, P., & Sointu, E. (2015). The impact of authentic learning experiences with ICT on pre-service teachers' intentions to use ICT for teaching and learning. Computers & Education, 81, 49–58. https://doi.org/10.1016/J.COMPEDU.2014.09.008
30. Zhao, J., Liu, E., & Sofeia, N. (2024). Whether perceived TPACK could improve deep learning? Through the lens of the mediating role of self-regulatory learning and the moderating role of technology self-efficacy in the online environment. Current Psychology, 43(37), 29848–29864. https://doi.org/10.1007/S12144-024-06455-X/METRICS
31. Zimmerman, B. J. (1986). Becoming a self-regulated learner: Which are the key subprocesses? Contemporary Educational Psychology, 11(4), 307–313. https://doi.org/10.1016/0361-476X(86)90027-5
32. Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64–70. https://doi.org/10.1207/S15430421TIP4102_2