Academic Self-Regulation Reimagined in Digital Era

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Abstract:
The digital era, accelerated by the widespread adoption of online platforms, blended learning, and generative artificial intelligence (GenAI) tools since 2020, has transformed academic learning into highly autonomous, flexible, and personalized yet demanding environments. Academic self-regulated learning (SRL)-the active, goal-directed process of planning, monitoring, controlling, and reflecting on cognition, motivation, behaviour, and context—has become an indispensable competency for success in these settings, where learners face constant distractions, information overload, algorithmic influences, and reduced external structure.
This conceptual paper critically evaluates and reconceptualizes three foundational SRL models—Zimmerman's cyclical model (forethought, performance, self-reflection), Pintrich's motivational framework (phases×cognitive/motivation/behavior/context areas), and Boekaerts's dual-processing model (mastery/growth vs. well-being/coping pathways)—in the context of AI-driven and online learning environments. While these models remain robust in their emphasis on agency, motivation, and iterative adaptation, they reveal critical limitations when applied to contemporary digital realities: insufficient theorization of technological co-regulation, algorithmic impact on agency, emotional dysregulation from constant interruptions, and challenges in dynamic, multimodal measurement.
The paper proposes a Digital-Augmented SRL (DA-SRL) hybrid framework that integrates the strengths of the three models with a new "AI co-regulation layer," expanded technological context regulation, and digital appraisal mechanisms. This reconceptualization preserves learner autonomy while leveraging GenAI affordances (personalized prompts, analytics, feedback loops) and mitigating risks (over-reliance, cognitive offloading, motivation decline). Practical implications for educators (embedding metacognitive scaffolds), learners (AI literacy and intentional toggling), and designers (transparent, regulation-focused tools) are discussed, alongside persistent barriers (digital divide, measurement ethics) and a future research agenda emphasizing longitudinal, multimodal, and equity-focused studies.
By bridging classic theory with the realities of AI-saturated education, this work contributes to educational psychology and technology-enhanced learning, offering pathways to cultivate resilient, self-directed learners in the digital age.

Keywords: Self-regulated learning, academic self-regulation, Zimmerman model, Pintrich model, Boekaerts model, digital era, AI-driven learning, generative AI, online learning, blended learning, metacognition, motivation regulation, digital co-regulation, technological context.

INTRODUCTION:

The rapid explosion of digital technologies has fundamentally transformed academic learning environments over the past decade, with the acceleration of online, blended, and AI-driven education becoming particularly pronounced after 2020. Learners worldwide routinely engage with massive open online courses (MOOCs), learning management systems (LMS) such as Moodle or Canvas, adaptive platforms, and increasingly generative artificial intelligence tools (e.g., ChatGPT, Gemini, and Claude) for content generation, personalized tutoring, feedback, and even assessment. These environments offer unprecedented flexibility, personalization, and access to knowledge, yet they also impose new demands on learners: high levels of autonomy, the ability to navigate information overload, resist distractions from notifications and multitasking, and maintain motivation in the absence of direct instructor presence.

Academic self-regulation (SRL), defined as the active, goal-directed process through which individuals plan, monitor, control, and reflect on their cognition, motivation, behaviour, and learning context to achieve academic goals (Zimmerman, 2000; Pintrich, 2000), has emerged as one of the most critical competencies for success in these digital landscapes. Empirical evidence consistently shows that effective SRL predicts higher achievement, persistence, and satisfaction in online and blended settings, whereas weak regulation is strongly associated with procrastination, disengagement, higher dropout rates (often exceeding 90% in MOOCs), and diminished learning outcomes (Xu et al., 2023; Faza & Lestari, 2025).

Three foundational models continue to dominate the SRL literature and provide robust theoretical anchors:

- **Zimmerman's cyclical model** (2000), rooted in social cognitive theory, conceptualizes SRL as a three-phase loop: forethought (goal-setting, planning, self-efficacy), performance (self-control, self-observation), and self-reflection (evaluation, attribution, adaptation).
- **Pintrich's motivational framework** (2000) organizes SRL across four phases (forethought/planning, monitoring, control, reaction/reflection) and four regulatory areas (cognitive, motivation/affect, behaviour, context), offering a broader, multi-dimensional perspective.
- **Boekaerts's dual-processing model** (1990s–2000) introduces parallel pathways: a mastery/growth-oriented pathway focused on learning goals and a well-being/coping pathway aimed at protecting emotional equilibrium, emphasizing the dynamic interplay between motivation, emotion, and task demands.

These models were originally developed in predominantly face-to-face or pre-digital contexts and have proven highly predictive of academic success. However, the digital era—marked by constant connectivity, algorithmic personalization, generative AI co-regulation, information abundance, and platform-induced distractions—introduces complexities that the original formulations do not fully anticipate or address. Recent systematic reviews and meta-analyses (2023–2025) highlight that while the core mechanisms of these models remain relevant, their application to technology-mediated environments reveals significant gaps: insufficient theorization of external technological scaffolds and co-regulation, limited consideration of algorithmic influence on agency, challenges in regulating emotion and motivation amid digital overload, and difficulties in measuring SRL dynamically in non-linear, interrupted online settings (Sharma et al., 2024; Faza & Lestari, 2025).

This conceptual paper critically evaluates and reconceptualizes the three classic models (Zimmerman, Pintrich, Boekaerts) to better suit AI-driven and online learning environments. It argues that adaptation is necessary to preserve learner agency, enhance metacognitive support, and integrate digital affordances without compromising the self-directed essence of SRL. The paper proceeds as follows: first, a detailed examination of the theoretical foundations and comparative strengths/limitations of the three models; second, an analysis of SRL opportunities and challenges in the digital era; third, a proposed reconceptualization with extended frameworks and practical implications; and finally, discussion of persistent barriers, recommendations, and future research directions.

By bridging classic theory with contemporary digital realities, this work contributes to educational psychology and technology-enhanced learning, offering educators, instructional designers, and learners clearer pathways to foster effective self-regulation in an increasingly AI-augmented academic landscape.

Theoretical Foundations: Classic Models of Self-Regulated Learning

Self-regulated learning (SRL) has evolved as a central construct in educational psychology since the 1980s, when researchers began distinguishing it from related concepts such as metacognition and learning strategies (Zimmerman, 1986; Pintrich et al., 1993). SRL is understood as an active, constructive process in which learners set goals, monitor progress, control their cognition, motivation, behavior, and context, and reflect on outcomes to achieve academic objectives (Zimmerman, 2000; Pintrich, 2000). Three foundational models—Zimmerman's cyclical model, Pintrich's motivational framework, and Boekaerts's dual-processing model—remain the most influential, frequently cited in contemporary research on digital and AI-mediated learning (Panadero, 2017; Faza & Lestari, 2025; Sharma et al., 2024).

Zimmerman's Cyclical Model

Barry J. Zimmerman's model, rooted in social cognitive theory (Bandura, 1986), conceptualizes SRL as a dynamic, recursive three-phase cycle: forethought, performance, and self-reflection (Zimmerman, 2000; Zimmerman & Moylan, 2009). In the forethought phase, learners engage in task analysis (goal-setting, strategic planning) and self-motivation beliefs (self-efficacy, outcome expectations, intrinsic interest/value). The performance phase involves self-control (self-instruction, attention focusing, self-observation) and self-observation (self-recording, self-experimentation). Finally, the self-reflection phase includes self-judgment (self-evaluation, causal attribution) and self-reaction (self-satisfaction/affect, adaptive/defensive inferences), which feed back into future forethought.

This model's strength lies in its iterative, feedback-driven structure, which emphasizes volition and agency. It has been the most widely adopted in recent digital SRL studies (51% of reports in one analysis; see Panadero et al., 2024), particularly for its applicability to adaptive systems where real-time performance data supports reflection. However, critics note its heavy focus on individual agency and behavioural subprocesses may underplay external technological influences and emotional dynamics in highly distracting digital contexts (Faza & Lestari, 2025).

Pintrich's Motivational Framework

Paul R. Pintrich's model organizes SRL into four general phases—forethought, planning, and activation; monitoring; control; and reaction and reflection—crossed with four regulatory areas: cognitive, motivation/affect, behaviour, and context (Pintrich, 2000). Cognitive regulation involves strategies like rehearsal and elaboration; motivation/affect includes goal orientation, self-efficacy, task value, and anxiety; behavioral regulation covers effort management and help-seeking; and context regulation addresses adapting to environmental demands.

Pintrich's framework stands out for its multidimensionality and strong integration of motivation, making it particularly relevant to digital environments where affective challenges (e.g., disengagement from overload) are prominent. The Motivated Strategies for Learning Questionnaire (MSLQ) derived from this model remains a standard self-report tool (Pintrich et al., 1991). Recent reviews praise its contextual area for addressing platform affordances, but critique its linear phase structure for not fully capturing the non-linear, interrupted nature of online learning (Sharma et al., 2024).

Boekaerts's Dual-Processing Model

Monique Boekaerts's model focuses on the interplay between two parallel pathways: the mastery/growth pathway (oriented toward learning goals, expansion of knowledge/skills) and the well-being/coping pathway (oriented toward protecting emotional equilibrium, ego, and commitment) (Boekaerts, 1996, 2006, 2007; Boekaerts & Niemivirta, 2000). Learners constantly appraise task demands against personal resources; positive appraisals activate the mastery pathway, while threat appraisals shift to coping, potentially at the expense of deep learning.

This model uniquely foregrounds emotion and motivation regulation, offering powerful explanations for digital distractions (e.g., switching to coping when overwhelmed by notifications). It has been applied in recent studies on digital fatigue and technostress (Xu et al., 2025). However, it is critiqued for giving less attention to detailed cognitive/metacognitive processes compared to Zimmerman or Pintrich, and for limited empirical traction in AI-specific SRL research (Panadero et al., 2024).

The three models share cyclical/recursive elements, multi-component structures, and emphasis on agency, but differ in focus: Zimmerman prioritizes behavioral volition and self-efficacy; Pintrich integrates motivation and context broadly; Boekaerts uniquely emphasizes emotional trade-offs and dual goals. All three remain highly relevant but require adaptation for the digital era's affordances (e.g., analytics, AI feedback) and challenges (e.g., overload, algorithmic influence), as highlighted in recent syntheses (Faza & Lestari, 2025; Sharma et al., 2024).

Self-Regulated Learning in the Digital Era: Opportunities and Challenges

The digital era, particularly since the acceleration of online and blended learning post-2020 and the emergence of generative AI (GenAI) tools by 2023, has profoundly reshaped the landscape of academic self-regulated learning (SRL). Learners now navigate environments characterized by high autonomy, vast information

access, personalized adaptive systems, real-time analytics, and AI-mediated support (e.g., ChatGPT for feedback, intelligent tutoring systems, and LMS dashboards). These shifts create both significant opportunities for enhanced regulation and formidable challenges that test the limits of classic SRL models (Faza & Lestari, 2025; Xu et al., 2023; Sharma et al., 2024).

Opportunities for SRL in Digital Environments

Digital technologies offer powerful affordances that amplify SRL processes across planning, monitoring, control, and reflection.

- **Personalization and Adaptive Support**: AI-driven platforms provide tailored content, scaffolding, and immediate feedback, supporting forethought (goal-setting) and performance phases. Learning analytics dashboards enable real-time monitoring of progress, while GenAI tools generate personalized prompts, summaries, or explanations, reducing cognitive load and enhancing metacognitive awareness (Faza & Lestari, 2025). Systematic reviews highlight that adaptive systems improve motivation and engagement by aligning tasks with learner needs (Sharma et al., 2024).
- **Multimodal Data and Reflection Tools**: Trace data (e.g., time on task, navigation patterns) combined with AI analytics facilitate accurate self-observation and reflection, surpassing traditional self-report methods. Prompting strategies in GenAI (e.g., "reflect on your strategy") foster metacognitive regulation (Xu et al., 2025). Collaborative platforms and forums support shared regulation, where peers or AI co-regulate processes (Sharma et al., 2024).
- **Motivation and Emotional Scaffolding**: Digital tools like gamification (badges, leaderboards) and motivational prompts boost effort regulation and task value. GenAI chatbots offer emotional support, helping learners switch between mastery and coping pathways (Boekaerts-inspired) during frustration (Xu et al., 2023).

Empirical syntheses indicate moderate to strong positive associations between SRL strategies (especially time management and effort regulation) and outcomes in online/blended settings, with technology-mediated interventions showing promise for persistence and achievement (Xu et al., 2023; Faza & Lestari, 2025).

Challenges and Limitations

Despite these benefits, the digital era introduces complexities that strain SRL capacities.

- **Distractions and Cognitive Overload**: Constant notifications, multitasking, and information abundance disrupt attention and monitoring, leading to procrastination and reduced deep processing (Faza & Lestari, 2025). Short-form content and algorithmic feeds exacerbate dopamine-driven interruptions, undermining sustained effort.
- **Over-Reliance and Metacognitive Laziness**: Frequent use of GenAI for content generation or answers can lead to cognitive offloading, diminished independent problem-solving, and reduced metacognitive engagement (Xu et al., 2025). Learners may overestimate understanding due to AI assistance, weakening self-reflection and adaptation (Sharma et al., 2024).
- **Motivation and Emotional Dysregulation**: High autonomy in online settings often results in motivation decline, especially when external structure is absent. Digital fatigue, technostress, and isolation amplify emotional challenges, pushing learners toward coping rather than mastery pathways (Boekaerts model).
- **Measurement and Equity Issues**: Traditional self-report tools (e.g., MSLQ) suffer from bias in digital contexts; multimodal data (traces, biometrics) is promising but raises privacy concerns. Digital divides exacerbate inequities, as access to supportive technologies varies by socio-economic status (Faza & Lestari, 2025).

Recent reviews conclude that while SRL predicts success in digital environments, challenges like over-dependence and distraction require new scaffolds and interventions to prevent erosion of core regulatory skills (Xu et al., 2023; Sharma et al., 2024).

In summary, the digital era amplifies SRL's potential through personalization and analytics but simultaneously intensifies demands on motivation, attention, and agency. These dynamics necessitate adaptation of classic models to preserve effective self-regulation amid technological affordances and pitfalls.

Reconceptualising the Classic Models for AI-Driven and Online Learning Environments

The classic models of self-regulated learning (SRL)—Zimmerman's cyclical model, Pintrich's motivational framework, and Boekaerts's dual-processing model—provide enduring foundations for understanding how learners actively direct their academic processes. However, the pervasive integration of generative AI (GenAI), adaptive learning platforms, learning analytics, and highly interactive online environments has introduced dynamics that the original formulations (developed pre-2010) do not fully anticipate. Algorithmic personalization, real-time feedback loops, cognitive offloading to AI, constant digital interruptions, and the blurring of individual vs. shared regulation demand a deliberate reconceptualization.

This section extends and reframes each model by incorporating digital/AI affordances and constraints, then proposes a **hybrid integrative framework** that synthesizes their strengths for contemporary technology-mediated learning. The goal is to preserve learner agency while leveraging technological scaffolds, addressing gaps identified in recent systematic reviews (Faza & Lestari, 2025; Sharma et al., 2024; Xu et al., 2025).

Reconceptualising Zimmerman's Cyclical Model

Zimmerman's three-phase cycle (forethought → performance → self-reflection) remains the most empirically dominant model in digital SRL research due to its clear iterative structure and emphasis on self-efficacy and volition (Panadero et al., 2024). In AI-driven environments, each phase can be enhanced as follows:

- **Forethought phase**: Digital tools support advanced goal-setting (e.g., AI-assisted SMART goal generators) and planning (adaptive calendars that suggest micro-goals based on learner patterns). However, algorithmic recommendations risk reducing perceived agency if goals are pre-set by the platform.
- **Performance phase**: Learning analytics dashboards provide real-time self-observation (e.g., time-on-task visualizations), while GenAI offers just-in-time self-instruction (e.g., "explain this concept in simpler terms"). The challenge is preventing over-reliance, which can weaken internal self-control.
- **Self-reflection phase**: AI-generated summaries of performance data facilitate accurate self-evaluation and attribution, but learners may attribute success/failure to AI rather than effort, undermining adaptive inferences.

Extension: Introduce a "digital co-regulation layer" to Zimmerman's cycle, where learners critically evaluate and override AI suggestions, maintaining volition while benefiting from external support.

Reconceptualising Pintrich's Motivational Framework

Pintrich's multi-dimensional model (phases × areas) offers the broadest scope, particularly its explicit treatment of motivation/affect and context regulation—crucial in digital settings where affective challenges (anxiety, boredom) and contextual demands (platform design, privacy) are amplified (Pintrich, 2000).

- **Motivation/affect area**: GenAI can enhance task value through personalized relevance (e.g., connecting content to learner interests), but algorithmic curation may reduce intrinsic motivation if content feels "fed" rather than discovered.
- **Context area**: Learners must now regulate algorithmic environments (e.g., adjusting AI prompt quality, managing data privacy, navigating notification settings), adding a new layer of meta-contextual regulation.
- **Cognitive and behavioural areas**: Adaptive platforms scaffold cognitive strategies (e.g., elaboration prompts), but over-scaffolding risks diminishing independent strategy development.

Extension: Expand the "context" area into "technological context regulation," including skills like prompt engineering, algorithmic literacy, and intentional toggling of AI assistance to balance support and autonomy.

Reconceptualising Boekaerts's Dual-Processing Model

Boekaerts's model, with its dual pathways (mastery/growth vs. well-being/coping), is uniquely positioned to explain emotional trade-offs in distracting digital spaces (Boekaerts, 2006). Constant notifications, multitasking demands, and AI-induced cognitive load frequently trigger shifts to the coping pathway.

- **Mastery pathway**: GenAI can accelerate growth by providing instant mastery support (e.g., personalized explanations), but may short-circuit deep processing if learners accept outputs without critical engagement.

- **Well-being pathway**: Digital stressors (technostress, FOMO from social features) activate coping more readily; AI companions can offer emotional scaffolding (e.g., motivational messages), but over-dependence risks emotional passivity.

Extension: Introduce a "digital appraisal filter" that explicitly accounts for how platform design (e.g., addictive feeds) and AI interaction style influence pathway switching. Learners must learn to recognize and interrupt unwanted shifts.

Proposed Hybrid Integrative Framework: Digital-Augmented SRL (DA-SRL)

Synthesizing the models yields a **Digital-Augmented SRL (DA-SRL)** framework with five integrated layers:

1. **Core Cyclical Process** (Zimmerman) — retains iterative phases as the backbone.
2. **Multi-Dimensional Regulation** (Pintrich) — adds motivation/affect and expanded technological context areas.
3. **Dual-Pathway Dynamics** (Boekaerts) — incorporates emotional trade-offs and appraisal under digital stressors.
4. **AI Co-Regulation Layer** — explicit metacognitive prompts, critical evaluation of AI outputs, and intentional toggling of assistance to prevent over-dependence.
5. **Multimodal Monitoring & Feedback** — integrates trace data, analytics, and AI-generated reflections for accurate, dynamic self-assessment.

Challenges, Implications, and Future Directions

While the reconceptualized Digital-Augmented SRL (DA-SRL) framework offers a promising synthesis of Zimmerman, Pintrich, and Boekaerts models for AI-driven and online learning environments, its effective implementation faces significant challenges. The rapid integration of generative AI and adaptive technologies has outpaced theoretical and practical scaffolding, revealing persistent barriers that threaten learner agency, equity, and long-term SRL development.

Key Challenges

1. **Over-Reliance and Erosion of Agency:** Frequent use of GenAI for content generation, summarization, or problem-solving can lead to cognitive offloading, where learners bypass independent planning, monitoring, and reflection (Xu et al., 2025). This risks creating "metacognitive illusions"—learners overestimate their understanding because AI provides accurate outputs, weakening self-efficacy and adaptive reflection (Faza & Lestari, 2025). Zimmerman's emphasis on volition and Pintrich's cognitive regulation are particularly vulnerable here.
2. **Distraction, Overload, and Emotional Dysregulation:** Constant notifications, algorithmic feeds, and multitasking demands amplify interruptions, pushing learners toward Boekaerts's coping pathway at the expense of mastery (Sharma et al., 2024). Technostress, digital fatigue, and motivation decline are widespread in online settings, especially when external structure is minimal (Xu et al., 2023).
3. **Equity and Access Issues** The digital divide persists: learners from low-resource backgrounds often lack reliable devices, high-speed internet, or AI literacy, limiting access to personalized scaffolds and analytics that support SRL (Faza & Lestari, 2025). This exacerbates disparities in self-regulation outcomes.
4. **Measurement and Assessment Difficulties** Traditional self-report instruments (e.g., MSLQ) suffer from bias and inaccuracy in digital contexts. While trace data and multimodal measures (e.g., eye-tracking, physiological sensors) are promising, they raise privacy concerns and are not yet scalable or ethically standardized (Sharma et al., 2024).
5. **Teacher and Institutional Readiness** Many instructors lack training in AI literacy, SRL scaffolding, or designing regulation-focused digital tasks. Institutional policies often prioritize content delivery over fostering self-regulation, limiting systemic support (Xu et al., 2025).

Implications for Practice and Policy

The challenges identified in the digital era of self-regulated learning (SRL) carry direct and actionable implications across multiple stakeholder groups. These are outlined below in a structured, point-wise format for clarity.

For Educators

- Explicitly integrate AI literacy as a core component of SRL instruction, teaching students how to critically evaluate AI-generated outputs for accuracy, bias, and relevance.
- Train learners in effective prompt engineering techniques to ensure AI assistance supports rather than replaces independent thinking.
- Teach intentional toggling of AI assistance — when to use it, when to work without it — to preserve learner agency and prevent cognitive offloading.
- Embed metacognitive prompts directly into LMS platforms and GenAI tools (e.g., "Explain in your own words why this AI suggestion is appropriate" or "What alternative strategy could you use without AI?").
- Use learning analytics dashboards formatively to guide student reflection on progress patterns (e.g., procrastination, over-dependence), while deliberately avoiding over-scaffolding that reduces self-direction.
- Participate in ongoing professional development focused on designing regulation-supportive digital environments and modeling SRL behaviors themselves.

For Learners

- Practice scheduled digital detox intervals (device-free periods) to restore focus and protect against constant interruptions.
- Utilize structured goal-setting apps that prompt phase-specific reflection (aligned with Zimmerman's cycle) to maintain clear, achievable objectives.
- Maintain personal self-reflection journals (digital or analog) to track motivation shifts, pathway switches (Boekaerts model), and recalibrate emotional responses.
- Develop regular self-monitoring routines (e.g., weekly review of platform usage data and time-on-task patterns) to balance mastery and coping pathways.
- Build habits of intentional pausing before accepting AI outputs, asking: "What did I learn from trying this independently first?"

For Instructional Designers and EdTech Developers

- Prioritize transparency and explainability in AI systems, clearly disclosing how recommendations or outputs are generated.
- Include opt-out/opt-in toggles for AI assistance at every major decision point to preserve learner choice.
- Build regulation-focused affordances such as built-in reflection prompts, progress visualizations, "pause & reflect" buttons, and strategy-selection menus.
- Incorporate gradual fading of scaffolds so that AI support decreases as the learner demonstrates stronger independent SRL.
- Adopt privacy-by-design principles to protect learner data used in analytics and personalization, ensuring ethical use and compliance with data protection regulations.

For Educational Institutions

- Revise assessment policies to value evidence of regulatory processes (e.g., reflection portfolios, strategy logs, process documentation) alongside content mastery.
- Allocate dedicated curriculum time for explicit SRL instruction and AI literacy within all programs.
- Invest in universal infrastructure equity (devices, reliable connectivity, offline-capable tools) to ensure all students can access regulation-supportive technologies.
- Establish institutional SRL goals and foster a culture that celebrates iteration, productive failure, and student voice in digital learning design.
- Provide ongoing teacher capacity-building programs specifically focused on AI-mediated SRL pedagogy and digital wellness.

For Policymakers and System-Level Stakeholders

- Formally integrate SRL competencies and digital/AI literacy (including ethical AI use and regulation strategies) into national curriculum frameworks with clear progression benchmarks.
- Prioritize equitable access to supportive technologies through subsidies, open-source platforms, and public digital infrastructure investments to bridge socio-economic divides.
- Fund large-scale, sustained continuous professional development (CPD) programs for teachers on designing and facilitating regulation-supportive digital environments.

- Commission and support longitudinal national studies to monitor the impact of GenAI and digital tools on SRL development, ensuring evidence-informed policy adjustments.
- Develop national guidelines for ethical use of AI in education, including standards for transparency, privacy, and prevention of over-dependence in learning systems.

These multi-level implications emphasize that effective SRL in the digital era is a shared responsibility — not solely the learner's burden, but a collective endeavor requiring aligned action from individuals, educators, designers, institutions, and policymakers to harness technology while safeguarding agency, motivation, and emotional well-being.

Future Research Directions

A robust research agenda is needed:

- Longitudinal studies tracking SRL development in GenAI environments.
- Multimodal assessment tools combining trace data, self-report, and physiological measures.
- Intervention studies testing hybrid scaffolds (e.g., metacognitive prompts in AI tools).
- Equity-focused research on digital divides and culturally responsive SRL strategies.

CONCLUSION:

To conclude, the digital era demands that we not only preserve but actively strengthen the core principles of Zimmerman, Pintrich, and Boekaerts—agency, motivation, emotion regulation, and iterative adaptation—while critically engaging with technology as both scaffold and potential threat. By reconceptualising these models through a digital-augmented lens, educators and learners can cultivate resilient, self-directed academic success in an increasingly AI-saturated world.

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